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Smoky Canyon Mine RI/FS

Feasibility Study Technical Memorandum #1: Identification and Screening of Remedial Technologies

March 2019

Prepared for:

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LIST OF ACRONYMS

95UCL	95 Percent Upper Confidence Limit
95USL	95 Percent Upper Simultaneous Limit
AMSL	Above Mean Sea Level
AOC	Administrative Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirement
BLM	United States Department of Interior Bureau of Land Management
BMP	Best Management Practice
BOD	Biological Oxygen Demand
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm/s	centimeters per second
CO	Consent Order
COD	Chemical Oxygen Demand
COC	Chemical of Concern
COPC	Chemical of Potential Concern
CSM	Conceptual Site Model
DEIS	Draft Environmental Impact Statement
EA	Environmental Assessment
EC	Exposure Concentration
ECOC	Ecological Chemical of Concern
EE/CA	Engineering Evaluation/Cost Analysis
EIS	Environmental Impact Statement
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
FBR	Fluidized Bed Bioreactor
FEIS	Final Environmental Impact Statement
FSTM	Feasibility Study Technical Memorandum
FWS	United States Department of Interior Fish and Wildlife Service
GCL	Geosynthetic Clay Liner
GCLL	Geosynthetic Clay Laminate Liner
GM	Geomembrane
gpm	gallons per minute
GRA	General Response Action
HH COC	Human Health Chemical of Concern
IDEQ	Idaho Department of Environmental Quality
IMA	Idaho Mining Association
MCL	Maximum Contaminant Level
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/kg dw	milligrams per kilogram dry weight
mg/L	milligrams per liter
MNA	Monitored Natural Attenuation
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NEPA	National Environmental Policy Act
NTCRA	Non-Time-Critical Removal Action
ODA	Overburden Disposal Area
OGC	Office of General Counsel

O&M	Operations and Maintenance
PRB	Permeable Reactive Barrier
PRG	Preliminary Remediation Goal
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
ROM	Run-of-Mine
SAP	Sampling and Analysis Plan
SEIS	Supplemental Environmental Impact Statement
SeWG	Selenium Working Group
SI	Site Investigation
Simplot	J.R. Simplot Company
SSERA	Site-Specific Ecological Risk Assessment
SSHHRA	Site Specific Human Health Risk Assessment
SSLRA	Site-Specific Livestock Risk Assessment
SOW	Statement of Work
SWPPP	Storm Water Pollution Prevention Plan
TBC	To Be Considered
TCLP	Toxicity Characteristic Leaching Procedure
T/E	Threatened and Endangered
Tribes	Shoshone-Bannock Tribes
TRV	Toxicity Reference Value
UF/RO	Ultrafiltration/Reverse Osmosis
USC	United States Code
USEPA	United States Environmental Protection Agency
USFS	United States Department of Agriculture Forest Service
USGS	United Stated Geological Survey
USMMS	United States Minerals Management Service
WTP	Water Treatment Plant

1.0 INTRODUCTION

The J.R. Simplot Company (Simplot) operates the Smoky Canyon Phosphate Mine (mine or Site) in southeast Idaho (Figure 1-1). The Smoky Canyon Mine is the subject of an Administrative Settlement Agreement and Order on Consent/Consent Order (Settlement Agreement/CO) for Performance of Remedial Investigation and Feasibility Study (RI/FS) entered into by the United States Department of Agriculture, Forest Service Region 4 (Forest Service [USFS]), United States Environmental Protection Agency Region 10 (USEPA), Idaho Department of Environmental Quality (IDEQ), and Simplot (USFS, USEPA, and IDEQ 2009), pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The Forest Service is the lead agency, and the USEPA, IDEQ, United States Department of Interior Fish and Wildlife Service (FWS) and Bureau of Land Management (BLM), and the Shoshone-Bannock Tribes (Tribes) participate as support agencies.

The Settlement Agreement/CO provides a mechanism to investigate the potential environmental effects of phosphate mining and milling operations at the Site and develop remedies to address any environmental conditions that represent a risk to human health or the environment. Section 4.1 of the Settlement Agreement/CO (USFS, USEPA, and IDEQ 2009), defines the "Site" as "the Smoky Canyon Phosphate Mine, which includes the areas of overburden disposal associated with the mine…the areal extent of contamination from the mine and overburden disposal areas and all suitable areas in very close proximity to the contamination necessary for response action implementation." The Settlement Agreement/CO supersedes that portion of the 2003 Administrative Order on Consent/Consent Order (AOC/CO; IDEQ, USFS, and USEPA 2003) associated with the Smoky Canyon Phosphate Mine (Area A) but does not address the Tailings Impoundments (Area B) (Figure 1-2). The 2003 AOC/CO remains in force with respect to Area B.

The general objective of the RI, as stated in the Settlement Agreement/CO (USFS, USEPA, and IDEQ 2009), is to determine the nature and extent of contamination and any threat to the public health, welfare, or the environment caused by the release or threatened release of hazardous substances, pollutants, or contaminants at or from the Site, and to assess risks to human health and the environment. Data collection under the RI site characterization effort was performed from spring 2010 through fall and winter 2012/2013 in accordance with the scope of work presented in the RI/FS Work Plan (Formation 2011a) and sampling procedures and locations described in the Sampling and Analysis Plan (SAP) (Formation 2010) and SAP Addenda 01 through 04 (Formation 2011d, 2011e, 2012b, 2012c). The findings of the investigation, including physical site characteristics, nature and extent of contamination, and fate and transport of chemicals of potential concern (COPCs), were detailed in the RI Report (Formation 2014c).

Three separate baseline risk assessments, a Site-Specific Human Health Risk Assessment (SSHHRA, Formation 2015a), Site-Specific Ecological Risk Assessment (SSERA, Formation 2015b), and Site-Specific Livestock Risk Assessment (SSLRA, Formation 2016a), were performed and reported following the RI site characterization. The methodology used in the SSHHRA was developed in conjunction with input from the regulatory agencies and was outlined in the SSHHRA Work Plan (Formation 2011b) and a technical memorandum that identified screening levels, exposure factors, and toxicity factors (SSHHRA Technical Memorandum, Formation 2013a). Similarly, for ecological receptors, the methodology used for the SSERA was presented in the SSERA Work Plan (Formation 2011c) and Baseline Problem Formulation (Formation 2013b). The approach used in the SSLRA was based on USEPA Ecological Risk Assessment (ERA) guidance (USEPA 1997, 1998) and is consistent with a screening-level risk assessment that allows for identification of COPCs that could be present at concentrations that are potentially toxic to livestock. Potential risks to human, ecological, and livestock receptors from exposure to contaminants at the Site were evaluated in these risk assessments.

The findings presented in the RI Report (Formation 2014c) and the risk assessments serve as the basis for identifying the Remedial Action Objectives (RAOs) for the Site and are used to support the development of remedial alternatives in this FS. The general objective of the FS, as stated in the Settlement Agreement/CO (USFS, USEPA, and IDEQ 2009), is to identify and evaluate alternatives for remedial action designed to prevent, mitigate, or otherwise respond to or remedy any release or threatened release of hazardous substances from the Site. The FS builds on the analyses presented in the Engineering Evaluation/Cost Analysis (EE/CA) (NewFields 2006a), which identified and evaluated a range of removal action alternatives to address unacceptable environmental conditions identified through the Site Investigation (SI) (NewFields 2005). Two of the removal action alternatives in the EE/CA for the Pole Canyon ODA were implemented as Non-Time-Critical Removal Actions (NTCRAs) (USFS, USEPA, and IDEQ 2006; USFS, IDEQ, and Tribes 2013) to address selenium loading to groundwater prior to and during the RI/FS process.

1.1 Purpose

Per the Settlement Agreement/CO and subsequent correspondence, the FS report is divided into two components, submitted as two separate deliverables (1) the development and screening of remedial alternatives and (2) the detailed analysis of alternatives. The purpose of FS Technical Memorandum #1 (FSTM#1), which is the first component of the FS process, is to identify and screen a range of remedial technologies and process options that will be assembled into Site-wide alternatives and evaluated in the detailed analysis. This technical memorandum, which follows USEPA's Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA 1988), originally included all of the elements set out in Section 8.a. of the Statement of Work (SOW). In accordance with September 8, 2017 Agency comments (USFS 2017) on Revised Draft FSTM#1, Section 5 of this technical memorandum evaluates technologies by environmental media using effectiveness, implementability, and cost. The rest of the elements in Section 8.a. of the SOW (assemble, refine, and screen remedial alternatives) will be included with the elements in Section 8.b. of the SOW in FSTM#2, which will document the second component of the FS process.

Alternatives will be developed by assembling combinations of technologies for specific environmental media that address contamination on a Site-wide basis or for specific overburden disposal areas (ODAs) and analyzed with respect to the evaluation criteria in the detailed analysis. The results of the development and detailed analysis of alternatives will be documented in FSTM#2. These two FS components will comprise the FS Report.

1.2 Site Location and Description

The Smoky Canyon Mine is located in Caribou County, Idaho (Figure 1-1), within the Southeast Idaho Phosphate Mining Resource Area. The mine is located approximately 24 miles due east of Soda Springs, Idaho and is accessed by traveling 10 miles generally west from Afton, Wyoming. The mining and milling operations are contained within 2,600 acres of federal phosphate mineral leases (Federal Phosphate Leases No. I-012890, I-026843, I-027801, I-27512, and I-30369) administered by the Pocatello Field Office of the BLM and approximately 1,200 acres of Special Use Permit administered by the Caribou-Targhee National Forest. Phosphate ore is extracted from a series of pits, referred to as mine panels, located on the eastern slope of the Webster Range between Smoky Canyon and South Fork Sage Creek (Figure 1-2). Specific mining and mine-related areas of the Site addressed in this FS include backfilled Panels A, B, C, D, and E; the external ODAs associated with these mine panels; and the Pole Canyon cross-valley fill ODA (Figure 1-3).

The mill and administrative and maintenance facilities are located in Smoky Canyon near the northern end of the mining operations. Mine Panel A is located immediately east of the mill, Panels B and C are north of the mill, and Panels D and E and the Pole Canyon ODA are south of the mill. The tailings ponds, which are not included within the Site as defined by the 2009 Settlement Agreement/CO, are located about 3 miles northeast of the mill in the Tygee Creek drainage on 1,680 acres of private land owned by Simplot. The mill is connected to the tailings ponds by a pipeline that extends through Smoky Canyon.

Mining activities began at Smoky Canyon in 1983 and are ongoing today. Ore is recovered through open pit mining practices that follow the north-south trending Phosphoria Formation outcrop as it dips to the west. Ore is recovered until the amount of overburden that must be removed to expose the ore (stripping ratio) becomes uneconomical. The overburden, which consists of Dinwoody, chert, limestone, and center waste shale, is used to backfill the previously mined pits and has also been placed in external ODAs just east of the pits to maintain efficient material balance as mining has progressed. Reclamation practices have changed over time, in response to the developing understanding of environmental conditions associated with releases from the overburden. Current practices entail grading to a 3:1 slope, placement of a cover, application of seed and fertilizer, and sometimes planting of shrubs and trees.

1.3 Investigations and Current Site Status

Previous investigations conducted at the Smoky Canyon Mine are described in detail in the RI Report (Formation 2014c) and include the following:

- 1981 Draft Environmental Impact Statement (EIS) – The United States Geological Survey (USGS), then in charge of administering phosphate mining on federal lands, prepared a Draft EIS (DEIS) for mining at Smoky Canyon in conjunction with the Forest Service (USFS and USGS 1981). The DEIS evaluated potential environmental impacts associated with the Smoky Canyon Project Mine and Reclamation Plan, submitted by Simplot in February 1981 (Simplot 1981).
- 1982 Final Environmental Impact Statement – The Final EIS (FEIS) was completed in 1982 (USFS and United States Minerals Management Service [USMMS] 1982), and the approval letter for the Project Mine and Reclamation Plan was signed in January 1983 (BLM 1983). The BLM letter included stipulations for the mine permit.
- 1990s Environmental Assessments (EAs) for Smoky Canyon Mine – Plans for individual mine phases were submitted to the regulatory agencies for review and approval (Panel A-4, BLM 1991; Panel D, BLM and USFS 1992; Panel E, BLM 1997).
- Mid-1990s Idaho Mining Association (IMA) Selenium Committee – The primary mine operators in the region formed the IMA Selenium Committee in order to jointly and voluntarily investigate and address mining-related environmental and public health issues associated with past operations.
- 2000 Area-Wide Administrative Order on Consent (AOC) – The AOC established the process used to conduct investigations and characterize risks associated with historical and active mining at an "Area-Wide" scale (IDEQ, USEPA, USFS, BLM, FWS, Bureau of Indian Affairs, and Tribes 2000).
- 2002 Panels B and C Supplemental EIS – A Supplemental EIS (SEIS) (BLM and USFS 2002) was conducted for the Smoky Canyon Mine Panels B and C areas to evaluate potential environmental impacts related to selenium releases and to establish new mitigation measures as needed to address these impacts. The Record of Decision (ROD) for Panels B and C was signed in 2002 (BLM 2002).
- 2002 Panels B and C Consent Order – A Consent Order was developed by IDEQ and Simplot for the protection of groundwater during Panels B and C mining activities (IDEQ 2002). The 2002 Consent Order provides for compliance with the Idaho Ground Water Quality Rule and also established a number of new monitoring requirements that are specific to the Panels B and C operations.
- 2003 Administrative Order on Consent/Consent Order (AOC/CO) – Simplot entered into an AOC/CO with IDEQ, USFS, BLM, and USEPA to evaluate and address the cumulative environmental and human health risks from current and historical mining operations at Smoky Canyon (IDEQ, USFS, and USEPA 2003). The 2003 AOC/CO established the responsibilities and schedules for performance of an SI and EE/CA for the Smoky Canyon

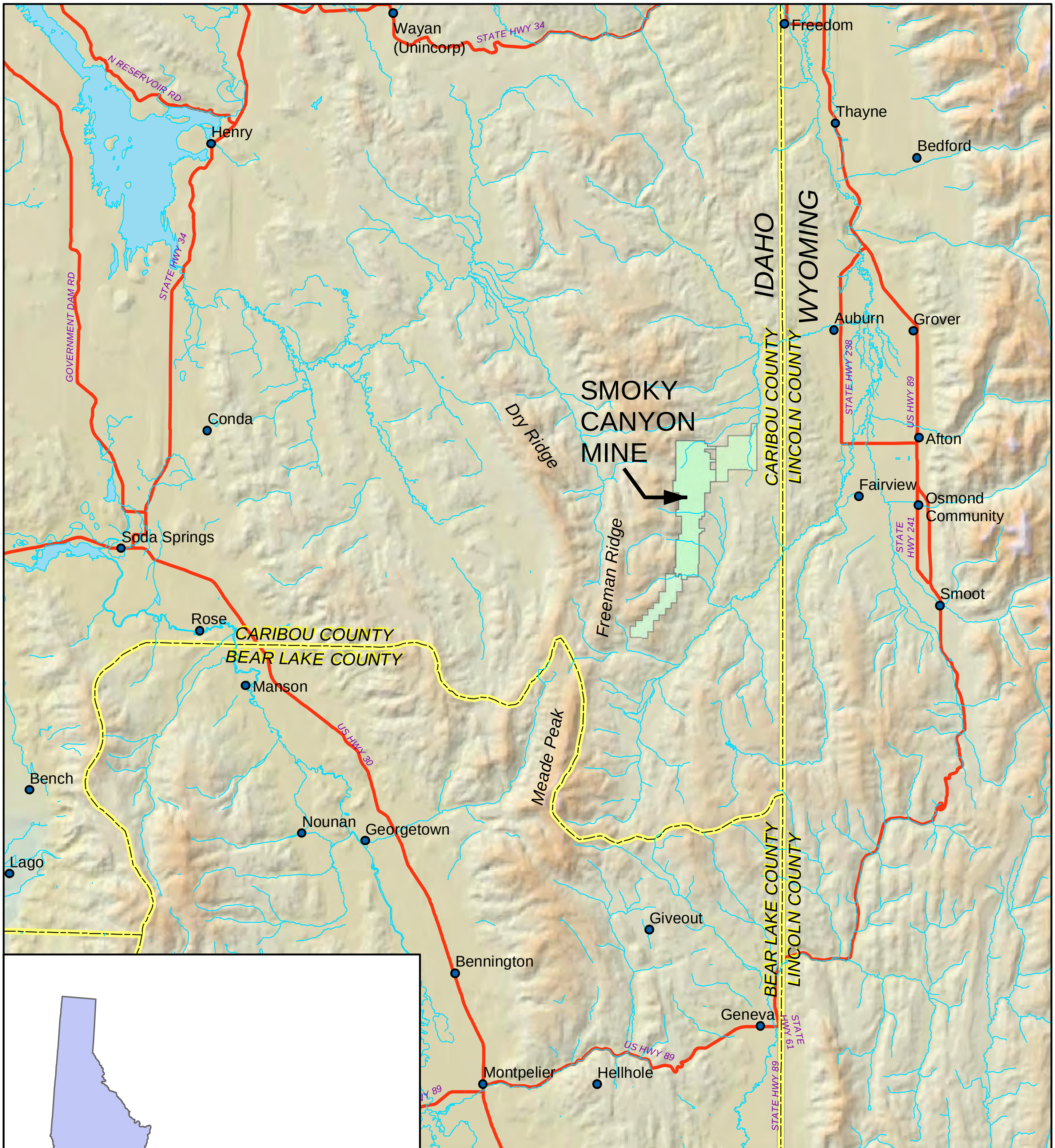
Phosphate Mine (Area A) and other necessary actions associated with the Tailings Impoundments (Area B) (NewFields 2005, 2006a).

- 2006 Settlement Agreement for Non-Time-Critical Removal Action (NTCRA) for the Pole Canyon ODA – Based on information provided in the SI and EE/CA, the Forest Service selected an NTCRA to address conditions associated with the Pole Canyon cross-valley fill ODA. In October 2006, Simplot entered into a Settlement Agreement with the Forest Service, USEPA, and IDEQ to implement the Pole Canyon 2006 NTCRA (USFS, USEPA, and IDEQ 2006).
- 2009 Administrative Settlement Agreement/CO for RI/FS – Simplot entered into a Settlement Agreement/CO for performance of an RI/FS for the Smoky Canyon Mine, including Panel B where mining is currently active (USFS, USEPA, IDEQ and 2009). The site characterization and risk assessments have been completed.
- 2012 EE/CA for NTCRA Alternatives at Pole Canyon ODA – An EE/CA was completed in 2012 (Formation 2012a) to identify and evaluate NTCRA alternatives that address conditions at the Pole Canyon ODA. Based on the EE/CA, the Forest Service selected a Dinwoody/Chert cover.
- 2013 Settlement Agreement for NTCRA for the Pole Canyon ODA – The Forest Service issued an Action Memorandum (USFS 2013a) to document approval of a Dinwoody/Chert cover for the Pole Canyon ODA as a Removal Action. The Dinwoody/Chert cover NTCRA was implemented under a separate Settlement Agreement for NTCRA entered into by the Forest Service, IDEQ, the Tribes, and Simplot in November 2013 (USFS, IDEQ, and Tribes 2013).

1.4 Document Organization

FSTM#1 is organized as follows:

- Section 2 summarizes information from the RI Report and the risk assessments, including site setting and physical characteristics, nature and extent of contamination, contaminant fate and transport, the conceptual model, and potential risks to human, ecological, and livestock receptors.
- Section 3 summarizes the environmental conditions of concern and presents Applicable and/or Relevant and Appropriate Requirements (ARARs), RAOs, and Preliminary Remediation Goals (PRGs).
- Section 4 identifies the General Response Actions (GRAs), remedial technologies, and process options potentially implementable to address the RAOs and describes the initial screening and evaluation process.
- Section 5 evaluates the remedial technologies/process options retained after the initial screening for the Site media of concern. Technologies/process options retained will be assembled into a range of remedial alternatives in FSTM#2.
- Section 6 lists references and data sources that were used to develop this technical memorandum.



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SMOKY CANYON MINE RI/FS
FEASIBILITY STUDY TECH MEMO #1

FIGURE 1-1

LOCATION OF THE SMOKY CANYON MINE

DATE: JULY 2018	FORMATION ENVIRONMENTAL
BY: CRL	FOR: ACK

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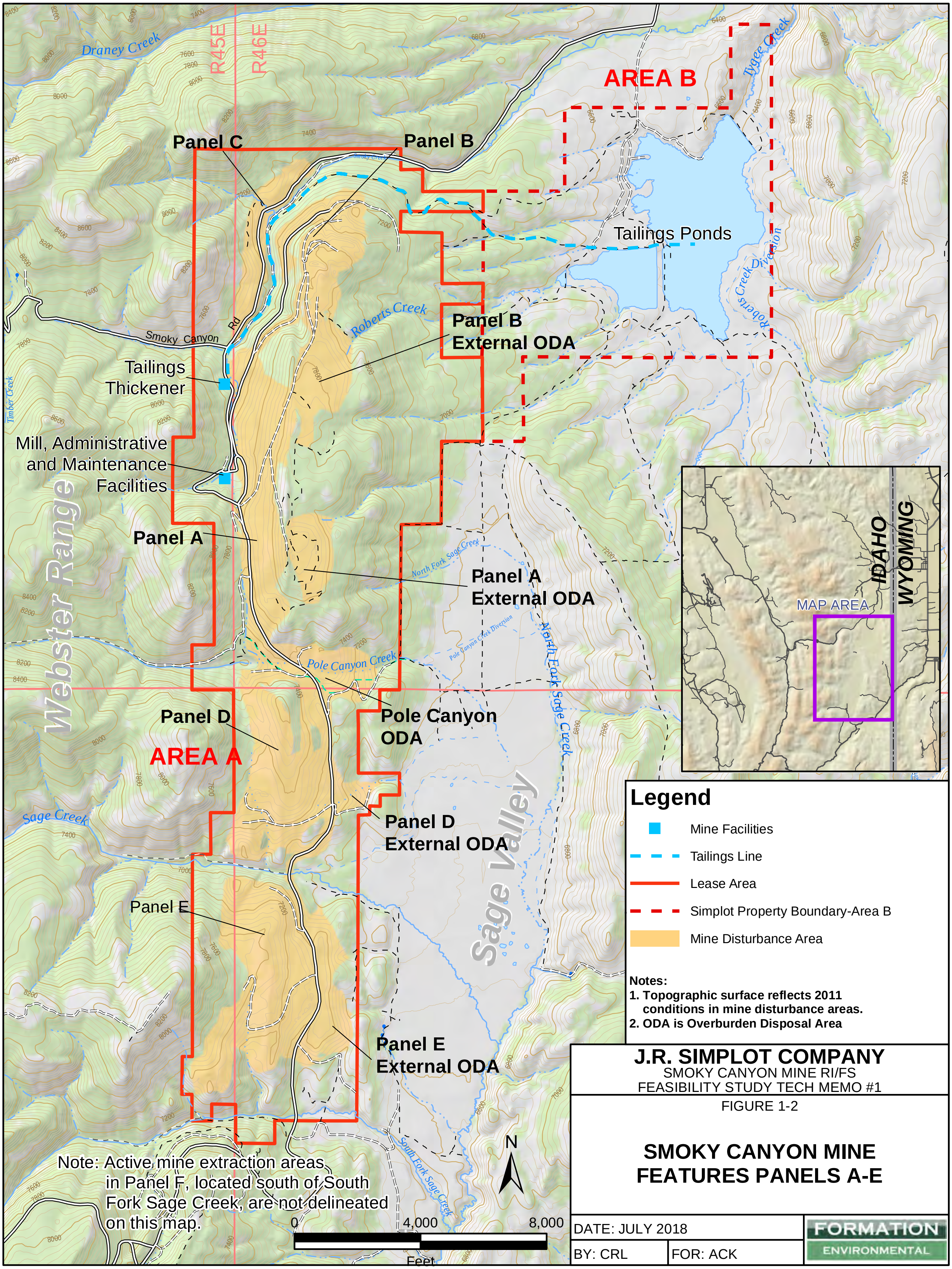

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FIGURE 1-2

SMOKY CANYON MINE FEATURES PANELS A-E

DATE: JULY 2018
BY: CRL
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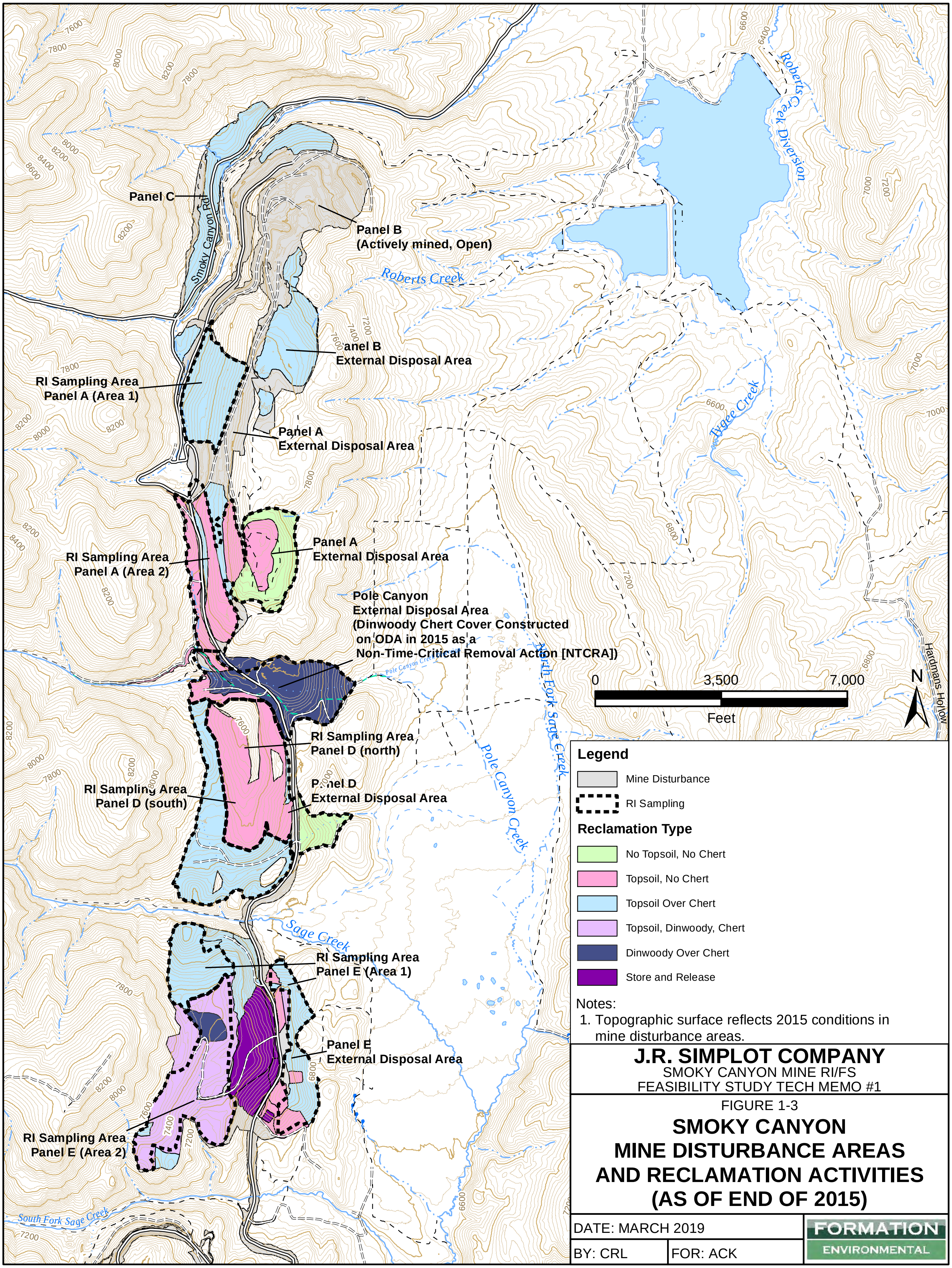

Notes:

1. Topographic surface reflects 2015 conditions in mine disturbance areas.

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FIGURE 1-3

SMOKY CANYON MINE DISTURBANCE AREAS AND RECLAMATION ACTIVITIES (AS OF END OF 2015)

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2.0 SUMMARY OF SITE CHARACTERISTICS AND RISKS

This section presents a summary of the conceptual site model (CSM) and site characterization information presented in the RI Report (Formation 2014c) and the risk evaluations presented in the SSHHRA (Formation 2015a), SSERA (Formation 2015b), and SSLRA (Formation 2016a). The focus of this summary is on the important physical and chemical characteristics and transport and exposure pathways relative to remedial alternative development and evaluation. Selenium is the primary contaminant in both solids and soil and groundwater and surface water and is the primary risk driver for ecological and livestock receptors. Selenium and arsenic in groundwater used as drinking water and ingestion of arsenic in water from seeps and detention ponds and arsenic in beef are the primary risk drivers for human receptors. The elevated concentrations of other COPCs coincided with selenium exposures in most cases. Therefore, the discussion in this section focuses on selenium, although when other COPCs are above levels of concern they are also noted.

2.1 Site Setting and Physical Characteristics

The Smoky Canyon Mine is located along the eastern slope of the north-south trending Webster Range just west of Sage Valley. Phosphate ore is extracted from the Phosphoria Formation in a series of pits between Smoky Canyon and South Fork Sage Creek that extend (north to south) for a distance of approximately 6 miles (Figure 1-2). Elevations at the Site range from 6,500 to 8,300 feet above mean sea level (AMSL). Information on the physical characteristics of the Site and surrounding areas has been collected to support the evaluation of the nature and extent of contamination, define potential contaminant transport pathways, and identify receptor populations.

2.1.1 Climate

The area in the vicinity of the Smoky Canyon Mine has a cool and dry climate, with typical prevailing winds and weather patterns moving from west to east. Annual precipitation of 14 to 28 inches has been measured at the Security Building at the mine, with the most abundant rainfall occurring in spring and early summer. In the winter months, snowfall averages 100 inches per year, and snow cover typically remains on the ground from November to April. Summer temperatures in the region normally range from 48 to 62 degrees Fahrenheit, while winter temperatures typically range from 12 to 26 degrees Fahrenheit.

2.1.2 Land Use

Much of the Smoky Canyon Mine is on National Forest System land, including the lease areas where mining takes place. Private ranch land owned by Simplot is located in Sage Valley immediately east of the mine panels. Other private lands (ranches and vacation homes) are located in the Crow Creek Valley south and southeast of the Site. The predominant land uses are associated with agriculture and natural resources and include crop production (primarily hay) on private lands along with cattle and sheep ranching on private and public lands. Phosphate mining, while not a dominant land use in terms of acreage, is economically important. On National Forest System land, recreational activities include hunting, fishing, camping, hiking, skiing, and snowmobiling, among others. Additionally, these lands may be used for Tribal hunting, fishing, and ceremonial activities consistent with the heritage of the Shoshone-Bannock Tribe. No residential use occurs at or adjacent to the Site. The closest population center is the Star Valley community, which includes the town of Afton, Wyoming, and is 10 miles directly east of the Site. The town of Afton has a population of approximately 1,800 (United States Census Bureau 2010).

2.1.3 Geology

The Smoky Canyon Mine is in the Idaho-Wyoming thrust belt and is underlain by the westward-dipping Meade thrust fault (Ralston and Mayo 1983). Movement on the thrust fault was from west to east. Strata within the thrust plate were folded into a series of north-south-trending anticlines and synclines that have been eroded into a series of ridges and valleys. Steep eastward-trending tear faults that developed during thrusting form small canyons dissecting these ridges (Armstrong and Cressman 1963). The mine is located on the west limb of the Boulder Creek Anticline, which is a north-south-trending, north-plunging fold. Figure 2-1 presents a geologic map of the Smoky Canyon Mine area compiled from Montgomery and Cheney (1967) and Connor (1980). Figure 2-2 provides an explanation of the map units. The anticline is truncated on the east by the West Sage Valley Branch Fault, which is an imbricate thrust of the Meade thrust fault (Mayo et al. 1985) and is a barrier to eastward groundwater flow. Thrusting along the fault has displaced older, highly fractured rocks eastward over younger relatively lower hydraulic conductivity rocks.

Sandstone and limestone of the Pennsylvanian/Permian Wells Formation forms the core of the Boulder Creek Anticline. The Wells Formation is overlain by the Permian Phosphoria Formation, which is exposed primarily along the west limb. The Phosphoria is the source of phosphate ore for the mine and is comprised of three members: the Meade Peak Phosphatic Shale Member, Rex Chert Member, and Cherty Shale Member. Seleniferous shale and chert are the primary types of overburden (i.e., run-of-mine [ROM] material) that are removed in order to access the ore. The overlying Triassic Dinwoody and Thaynes formations are composed of shale, siltstone, and limestone, and are exposed west of the mine within the Webster Syncline, north of the mine where the anticline plunges into the subsurface, and east of the mine in Sage Valley. Bedrock in the valley is overlain by silty limestones of the Tertiary Salt Lake Formation and Quaternary sediments. Colluvial gravel and sand form fan-shaped deposits in South Fork Sage Creek, Sage Creek, and Pole Canyon Creek where the creeks emerge from the foothills and flow into Sage Valley. Alluvial sand and gravel is deposited by North Fork Sage Creek on the floor of Sage Valley.

2.1.4 Groundwater

Groundwater occurs in two aquifer systems at the Smoky Canyon Mine (1) the shallow alluvial groundwater system and (2) the deep Wells Formation aquifer.

The shallow alluvial groundwater system consists of thin, narrow, unconsolidated, surface deposits that are locally present along the natural stream channels that transect the mine area and receive recharge from the surface at and in the vicinity of the Site. Along the west side of Sage Valley, these local stream channel deposits transition to much thicker and laterally extensive colluvial and alluvial deposits that cover the floor of northern Sage Valley and fill in between bedrock highs in lower Sage Valley (Figure 2-1). The valley-fill groundwater system discharges to Sage Creek along several stream segments.

Regional groundwater flow in the deep Wells Formation aquifer is controlled by (1) the elevation of recharge areas on Freeman Ridge and Dry Ridge to the west and Meade Peak to the south (see locations on Figure 1-1), (2) the elevations of two major discharges from the aquifer—Hoopes Spring and South Fork Sage Creek springs—located east of Panel E (see spring locations on Figure 2-1), and (3) the effects of local structural features such as the West Sage Valley Branch Fault. The Wells Formation aquifer receives local recharge from precipitation in outcrop areas along the Boulder Creek Anticline and infiltration from streams crossing outcrop areas (Figure 2-1). In the vicinity of the Site, streams flowing eastward generally gain flow as they cross the Dinwoody outcrop west of the mine, remain constant in terms of flow across the Phosphoria Formation, and then lose flow as they cross the Wells Formation outcrop.

Most of the backfilled pits and ODAs at the mine overlie Wells Formation outcrops and subcrops. The Wells Formation aquifer lies several hundred feet or more below the backfilled pits and ODAs and is separated from them by unsaturated Wells Formation limestone. Groundwater elevations exhibit seasonal fluctuations. Except for the Wells Formation groundwater captured by the Industrial Well, Site groundwater within the Wells Formation aquifer generally flows to the east and south. Groundwater flow in the upper Wells Formation aquifer is controlled by the combined effects of the West Sage Valley Branch Fault, which is a barrier to flow to the east, and the discharge zone created by Hoopes Spring and South Fork Sage Creek springs (the "springs complex"). Discharge from the springs complex comprises the majority of flow in the lower Sage Creek drainage under all flow conditions. The springs complex creates a capture zone that prevents groundwater flow to the south. Figure 2-3 is a potentiometric map that shows groundwater flow directions under current conditions during pumping at the Industrial Well. The flow directions and gradients vary seasonally.

2.1.5 Surface Water

The slopes of the Smoky Canyon Mine generally drain eastward with streams flowing into the Salt River, which joins the Snake River and ultimately the Columbia River. Surface water at the Site occurs within two drainage basins: the Tygee Creek basin in the north end of the Site and the Sage Creek basin in the south end (Figure 2-4).

The Tygee Creek basin includes the drainages of Smoky Creek, Roberts Creek, and Lower Tygee Creek and drains to Stump Creek. Draney Creek and Webster Creek are also within the Tygee Creek drainage basin north of the Site. Panels B and C and the northern portion of Panel A are located in the Tygee Creek basin. Smoky Creek crosses mine-disturbance areas in Panel A but does not receive runoff from these areas. Surface runoff from Panel A is diverted to storm water detention basins. Data collected during the RI showed that no water was discharged from the detention basins in the Panel A area (Formation 2014c).

The Sage Creek basin includes the drainages of North Fork Sage Creek, Pole Canyon Creek, Sage Creek, and South Fork Sage Creek and drains to Crow Creek. Panels D and E, the Pole Canyon ODA, and the southern portion of Panel A are located within the Sage Creek basin. Pole Canyon Creek, Sage Creek, and South Fork Sage Creek cross these mine panels but do not receive runoff from these mine-disturbance areas. However, certain creeks do receive groundwater discharged from either the alluvial flow system or the Wells Formation aquifer. Lower Pole Canyon Creek flows into Sage Valley, but generally loses flow to the alluvial groundwater system before reaching North Fork Sage Creek. Wells Formation groundwater that discharges at Hoopes Spring and South Fork Sage Creek springs continues downstream into Sage Creek and South Fork Sage Creek. Sage Creek flow typically remains constant through lower Sage Valley and into the Crow Creek drainage.

2.1.6 Ecology

Several vegetation or habitat types have been identified within and around the Smoky Canyon Mine (Maxim 2002). Higher elevation areas and north- and west-facing slopes receive sufficient moisture to support subalpine fir and Engelmann spruce, and mid-elevation areas are represented by Douglas-fir and aspen. Forest openings are dominated by a mixed shrub component that includes mountain snowberry and antelope bitterbrush. The warmer and drier lower elevation areas and south-facing slopes are typified by mixed shrub communities of sagebrush and various grassland species. Riparian areas are dominated by willows, sedges, and reed grass, and watercress is commonly found at Hoopes Spring and in Sage Creek.

The diverse vegetation types found at the Site provide habitat for a variety of wildlife species (BLM and USFS 2002). Mammals include bats, rabbits, rodents, black bear, mountain lion, mule deer, elk, and moose. Numerous bird species occur in the area, including raptors and passerines.

Game birds such as grouse are also present. Cutthroat trout, brook trout, rainbow trout, brown trout, dace, sculpin, redside shiner, chub, and a wide variety of macroinvertebrates have been documented in area streams. Amphibian and reptile species known to occur include tiger salamander, rubber boa, and western terrestrial garter snakes.

The only federally-listed threatened and endangered (T/E) species in Caribou County is the Canada lynx (*Lynx canadensis*) (FWS 2013). Although potential "linkage" habitat for the lynx is present (Ruediger et al. 2000; USFS 2007), surveys for lynx indicate that this species is not present in the Smoky Canyon Mine area (Maxim 2002, 2004; BLM and USFS 2007). The same habitat is also potentially suitable for the gray wolf (*Canis lupus*). In May 2011, the FWS published a direct final rule delisting the gray wolf in Idaho (FWS 2011).

2.1.7 Status of Mining and Reclamation

The progression of mining and reclamation at the Smoky Canyon Mine is presented in appendices to the RI Report (Formation 2014c) and is based on maps prepared from mine disturbance and reclamation data, elevation information, aerial images, and panel chronology. The status of mining and reclamation in the various mine panels is as follows (using approximate mine panel and ODA reclamation areas from the RI Report):

- Panel A and External ODAs – Panel A covers approximately 245 acres; the external ODAs cover 135 acres. Mining at Panel A took place from 1985 to 1990. Pits A-1, A-2, and A-3 were backfilled shortly after mining and covered with topsoil or reclaimed by direct revegetation. Pit A-3 is partially regraded and will be backfilled and reclaimed as part of ongoing mining operations in Panel B.
- Panel B and External ODA – Panel B covers approximately 155 acres; the external ODA covers approximately 50 acres. Mining at Panel B took place from 2004 to 2010. Overburden from Panel B was used to backfill Pits B-1 and B-3 and the remainder was placed in an external ODA. Reclamation activities for the external ODA and the lower portion of Pits B-1 and B-3 have been completed with a topsoil over chert cover. Mining is continuing in Pits B-2 and B-4.
- Panel C – Panel C covers approximately 105 acres and was mined from 2002 to 2006. Panel C is backfilled with overburden from Panels B and C. The northern end of Panel C (approximately 45 acres) was reclaimed in 2008 and the remainder of Panel C was reclaimed in 2010 with a topsoil-over-chert cover.
- Panel D and External ODA – Panel D covers approximately 270 acres; the external ODA covers 90 acres. Mining at Panel D took place from 1993 to 1998 in three pits (Pits D-1, D-2, and D-3). Panel D overburden was placed in an external ODA as well as in portions of the Pole Canyon ODA. The pits and overburden areas were reclaimed in 2002 by direct revegetation or covered with topsoil only or topsoil over chert.
- Panel E and External ODA – Panel E contains a total of five pits (Pits E-0, E-1n, E-1s, E-2, and E-3) and covers approximately 390 acres; the external ODA covers 120 acres. Mining in Panel E began in 1998 in Pit E-1n and continued through 2006. Reclamation of this pit and the external ODA was completed in 2003 with topsoil-over-chert or a

Dinwoody/Chert cover. Mining began in the other pits in Panel E in 2000 and 2001. Backfilling of Pits E-2 and E-3 began in 2003. Pits E-1s, E-2, and E-3 were reclaimed with a Dinwoody/Chert cover in 2008. Pit E-0 was backfilled with overburden from Panel F in 2010. Pit E-0 was covered with a Deep Dinwoody store and release cover system in 2014.

- Pole Canyon ODA – The Pole Canyon ODA is an external disposal area that covers approximately 130 acres in the Pole Canyon Creek drainage. The Pole Canyon ODA was constructed as a cross-valley fill over Pole Canyon Creek. Most of the overburden originated from Panel A, which was mined from 1985 to 1990. A much smaller portion of the overburden originated from Panel D (Pit D-2) and was placed on the west side of the ODA in 1997. Two NTCRAs were completed at the Pole Canyon ODA in 2008 and 2015, as discussed below. The ODA was reclaimed in 2015 with a Dinwoody over chert cover.

A summary of reclamation areas and cover types is shown on Figure 1-3 and listed in Table 2-1.

2.1.8 Non-Time-Critical Removal Actions

Two NTCRAs have been completed at the Pole Canyon ODA. The first was implemented under a Settlement Agreement/CO (USFS, USEPA, and IDEQ 2006) to reduce the rate of selenium transport from the Pole Canyon ODA to the environment thereby improving downstream and downgradient water quality. This first NTCRA is referred to herein as the "2006 NTCRA." Construction of the 2006 NTCRA was completed in 2008 and included:

- A bypass pipeline to divert Pole Canyon Creek stream flow around the ODA and directly into Sage Valley
- An infiltration basin that directs clean flow from Pole Canyon Creek in the area between the pipeline diversion inlet and the upstream toe of the ODA to the Wells Formation aquifer
- A channel to prevent run-on to the Pole Canyon ODA from the northern hillside slope.

The second NTCRA, referred to as the "2013 NTCRA," was implemented under a separate Settlement Agreement/CO entered into by the Forest Service, IDEQ, the Tribes, and Simplot in November 2013 (USFS, IDEQ, and Tribes 2013), to reduce or eliminate the amount of precipitation that infiltrates into the ODA, reduce or eliminate risks due to ingestion of vegetation and direct contact with ODA materials, and eliminate the release of contaminants from the ODA via sediment transport. Construction of the 2013 NTCRA was substantially completed in 2015 and entailed:

- Grading the surface of the ODA,
- Covering the ODA with chert/limestone averaging 2 feet in thickness overlain by 3 feet of Dinwoody material,
- Revegetating the Dinwoody surface with native non-selenium accumulating species, and
- Constructing storm water run-on/runoff controls to convey water off the ODA.

2.1.9 Pilot Studies

Per the RI/FS Settlement Agreement/CO (USFS, USEPA, and IDEQ 2009) requirements, Simplot prepared a technical memorandum to provide an evaluation of available water-treatment technologies and identify the technologies that appear most suitable for the Site (NewFields and Formation 2009). The likelihood for further evaluation of these technologies through the FS process of remedial alternative development was determined based on the level of demonstrated effectiveness, commercial availability, use of resources, and overall ease of implementation at the Site. Based on the findings of the 2009 Surface Water Treatability Study Technical Memorandum, the following pilot studies have been implemented at the Site to evaluate the performance of technologies with the highest potential for use as remedial actions:

- 2009 – GE ABMet® active, anoxic/anaerobic, biological process at the DS-7 seep and also at the nearby Conda Mine
- 2009 – Zero-valent iron technology at South Fork Sage Creek
- 2010 – Reverse osmosis at Hoopes Springs
- 2013 (ongoing) – Semi-passive biological treatment technology at the DS-7 seep.

These treatment technologies are discussed in detail in an addendum (Formation 2014a) to the technical memorandum cited above. The major findings from these studies were as follows:

- Passive treatment of spring discharges by zero-valent iron technology is not effective in meeting the surface water quality criterion for selenium.
- Concentration by reverse osmosis is a viable option to concentrate contaminants for removal by other treatment technologies.
- Passive and semi-passive biological reduction treatment may be an option for seeps that do not discharge into surface waters, and where significant removal of selenium (rather than meeting the surface water quality criterion for selenium) may be an appropriate goal.
- Active treatment by biological reduction is effective and can meet the surface water quality criterion for selenium. Biological oxygen demand (BOD) and chemical oxygen demand (COD) were monitored in the effluent discharged after treatment. Constituents added to the water stream as a result of treatment included ammonia, phosphorus, and total organic carbon. Temperature increased, and pH and dissolved oxygen decreased in the effluent, compared to the influent. The required discharge limits depend on the setting of the system (i.e., discharging to surface water, mixing zones, upstream concentrations, etc.). The BOD/COD levels in the discharge need to be considered to evaluate the effect on dissolved oxygen levels in the receiving stream. Additional polishing of water quality is necessary before treated effluent can be discharged to nearby streams, especially for larger-flow systems.

Two other pilot studies were implemented in 2005 prior to initiation of the RI/FS at seeps associated with external ODAs to isolate seep water that wildlife and livestock may use as drinking water sources. One of the pilot studies was implemented at detention basin DP-10, which is adjacent to a haul road in Panel D. The study involved elimination of the basin by removal of the constructed berms and installation of a chert cover over the area (NewFields 2004a). Upon completion, the potential for wildlife contact with water in the DP-10 basin and associated vegetation immediately downslope of the basin was eliminated. Visual monitoring indicates that this measure has been effective in eliminating the potential for exposure.

The other pilot study was implemented to address water from snowmelt and storm water that emanated from the southwest toe of the Panel E ODA (seep ES-5) and then flowed along the ground surface before infiltrating. Pilot study work included overburden recontouring to limit future discharge of seep water to the surface in the ES-5 area and placement of a chert cover over the ground surface where seep water flowed (NewFields 2004b). No flow from the ES-5 seep area has been observed after these actions were completed.

2.2 Nature and Extent of Contamination

The RI confirmed previous SI findings that overburden disposed in backfilled mine pits and external ODAs is the source of selenium and other COPCs to the environment. Overburden is removed during active mining to access the underlying phosphate ore. The primary sources of selenium and other COPCs within the overburden are the sulfides and organic matter present in the mudstone and center waste shale from the Meade Peak Member of the Phosphoria Formation. Selenium and other COPCs are released from overburden materials to infiltrating and percolating water. Transport to Wells Formation groundwater and discharge to surface water via Hoopes Spring and South Fork Sage Creek springs is considered the primary mechanism for transport of selenium to the environment.

The physical setting of the different backfilled pits and external ODAs at the Site and the type of reclamation completed on each influences the relative importance of these sources in terms of mass flux of selenium and other COPCs released and transported. Less protective covers (including direct revegetation) allow greater infiltration of precipitation resulting in larger contributions of selenium and other COPCs to the underlying groundwater. More recent Dinwoody/Chert covers are more effective in reducing infiltration. The Pole Canyon ODA is distinct from the other ODAs at the Site because of the cross-valley fill setting (with Pole Canyon Creek flowing through the ODA prior to the 2006 NTCRA) and the presence of an underlying shallow alluvial groundwater system associated with Pole Canyon Creek.

2.2.1 Soil and Vegetation

<u>Soil</u>

Selenium concentrations on the surface of ODAs with less protective covers are elevated due to the presence of seleniferous shale in the ROM overburden. There is no significant physical transport (i.e., erosion) of these materials at the Site. Thicker covers of topsoil or other geologic material generally result in lower concentrations of selenium at and near the surface. Reclamation areas and cover types for each of the mine panels are shown on Figure 1-3 and listed in Table 2-1. The highest mean selenium concentrations in soil were measured on Panel A Area 2 (topsoil cover), the Pole Canyon ODA prior to the 2013 NTCRA (no cover), Panel D South (topsoil-over-chert cover), and Panel D North (topsoil cover). The lowest mean selenium concentrations were measured on Panel A Area 1 (topsoil over Dinwoody/Chert cover), Panel E Area 1 (topsoil-over-chert cover), and Panel E Area 2 (topsoil over Dinwoody/Chert cover). The mean selenium concentration for soils sampled on Panel A Area 1 and Panel E was similar to the mean concentration for soils sampled in northern Sage Valley. Since the RI was completed in 2014, exposure to overburden material in soils on the Pole Canyon ODA has been addressed under the 2013 NTCRA (USFS, IDEQ, and Tribes 2013) with a Dinwoody/Chert cover, completed in 2015.

Selenium concentrations were generally low in soils adjacent to the ODAs, with exceptions in some of the seep areas. Sheet or rill erosion does not lead to widespread contamination of soils that are downgradient from the ODA source areas either during mining or shortly after mining is completed before reclamation occurs.

Surface transport of selenium from surface water to soil is limited to the immediate areas of overburden seepage and was not observed in northern Sage Valley, with the exception of elevated concentrations within a small occasionally wet area that may either periodically receive surface water flow from Pole Canyon Creek or exhibit periodic expressions of shallow groundwater.

<u>Vegetation</u>

Terrestrial vegetation was collected at many of the same locations where soil samples were collected including vegetation growing on ODAs and in adjacent soils. Uptake of selenium by vegetation growing on ODAs with less protective covers was identified as a potential exposure pathway for ecological receptors specifically in the Panel A Area 2, Pole Canyon ODA (prior to the 2013 NTCRA), Panel D South, and Panel D North areas. Plant uptake of selenium also occurs in soils that are saturated with water originating from overburden seeps, with localized effects of seeps on selenium concentrations in vegetation focused on vegetation where the root zone is consistently saturated with seep water. Selenium concentrations in vegetation are generally correlated with selenium concentrations in the soil. The highest mean selenium concentrations in soil on overburden areas were measured on Panel A (27 milligrams per kilogram [mg/kg]), the Pole Canyon ODA (19 mg/kg; note that this was before the NTCRA cover was constructed), and Panel D (14 mg/kg). Similarly, the highest mean selenium concentrations from composite vegetation samples were measured on Panel A (24 mg/kg), the Pole Canyon ODA (10 mg/kg), and Panel D (13 mg/kg). Selenium concentrations in vegetation are lower when the mine pit or ODA has been reclaimed using a cover system comprised of non-seleniferous materials, such as the Dinwoody/Chert cover which has been constructed on Panel E. Mean selenium concentrations in soil (0.32 mg/kg) and vegetation (0.15 mg/kg) at Panel E Area 2 were significantly lower. Elevated concentrations of arsenic are present in vegetation where overburden is at the surface, and this was identified as posing a potentially unacceptable risk to human receptors consuming beef from livestock that graze in these areas.

Selenium accumulation into plants is of particular interest at the Site. Based on surveys conducted during site characterization for the RI, selenium hyperaccumulator (e.g., *Astragulus*) and accumulator (e.g., *Aster*) plant species are absent from much of the Site which may be due in part to an herbicide program. None of the species listed by Mackowiak and Amacher (2010) as hyperaccumulators (plants accumulating selenium at concentrations greater than 500 mg/kg) or accumulators (plants accumulating selenium at concentrations from 50 to 100 mg/kg) were observed in any of the transect locations nor in any of the composite samples collected for the RI (Formation 2014c). However, alfalfa (*Medicago sativa*) is common in some of the reclaimed areas of the Site and elsewhere in the region and is considered a selenium accumulator. Two vegetation samples collected at seeps at the Pole Canyon ODA and at Panel E contained selenium between 100 and 500 mg/kg. These included a forb sample collected downstream from LP-1 (with 153 mg/kg selenium) that contained yellow sweet clover (*Melilotus* spp.), which is considered a probable selenium accumulator by Guo and Wu (1998), Hambuckers et al. (2008), and Kostopoulou et al. (2010), and a forage sample collected at ES-4 (with 149 mg/kg selenium) that did not contain any selenium hyperaccumulator or accumulator species.

2.2.2 Wells Formation and Alluvial Groundwater

Exceedances of the Maximum Contaminant Level (MCL), also the Idaho drinking water standard, of 0.05 milligrams per liter (mg/L) for selenium were observed in Wells Formation groundwater and alluvial groundwater downgradient of source areas, for example, at several wells immediately downgradient of the Pole Canyon ODA. However, selenium concentrations in groundwater from all other locations were lower than the drinking water standard. These wells downgradient of the Pole Canyon ODA also contained arsenic concentrations that exceeded the Idaho drinking water standard (0.01 mg/L) and are known to be affected by past infiltration of water into the ODA, and downgradient transport in alluvial and Wells Formation groundwater.

<u>Wells Formation Groundwater</u>

Specifically, for the Wells Formation groundwater aquifer, selenium is present above the 0.05 mg/L groundwater MCL downgradient of source areas (at the Industrial Well and for monitoring wells GW-16 and GW-25), and above the State of Idaho Surface Water Quality Criterion for Aquatic Life (aquatic water quality standard) of 5 micrograms per liter (µg/L) where groundwater discharges to surface water at Hoopes Spring and South Fork Sage Creek springs. Selenium concentrations in the springs have been increasing recently, with individual measurements within the springs complex over the past several years ranging from approximately 0.03 to 0.134 mg/L (Hoopes Spring) and from less than 0.01 to 0.099 mg/L (South Fork Sage Creek springs).

In the Panels A and C area, samples collected at the Industrial Well since the early 2000s indicate a slowly increasing baseline selenium concentration and a pattern of concentration spikes that typically occur in the middle of the calendar year, during late spring and early summer recharge conditions. The total selenium concentration in the Industrial Well reached a high of 0.126 mg/L in the sample collected in June 2011, but the concentration has remained at approximately 0.03 mg/L since then.

For Wells Formation groundwater, exceedances of groundwater MCLs for non-selenium COPCs were observed for aluminum, arsenic, iron, and manganese for some of the samples collected at several of the monitoring wells. However, these exceedances were not as consistent as those identified for selenium in Wells Formation groundwater and were typically co-located with elevated selenium concentrations.

<u>Alluvial Groundwater</u>

The extent of the alluvial groundwater system is limited to the lower portions of Pole Canyon, South Fork Sage Creek, and Sage Valley; therefore, the Pole Canyon ODA is the only source area that contributes water to the alluvial groundwater flow system. Selenium concentrations are highest in shallow groundwater immediately downgradient of the Pole Canyon ODA adjacent to lower Pole Canyon Creek (see GW-15 on Figure 2-1). Selenium concentrations in alluvial groundwater decrease southward from the lower Pole Canyon area toward the north-central portion of Sage Valley.

Gain-loss surveys for Sage Creek identified several stream segments where discharge from the valley alluvial flow system to Sage Creek was occurring. However, no increase in the Sage Creek selenium load could be attributed to discharging alluvial groundwater. The selenium load to alluvial groundwater has decreased significantly as a result of the 2006 NTCRA at the Pole Canyon ODA.

For alluvial groundwater, exceedances of groundwater MCLs for non-selenium COPCs were observed for aluminum and arsenic for some of the samples collected at several of the monitoring wells. However, these exceedances were not as consistent as those identified for selenium in alluvial groundwater and were typically co-located with elevated selenium concentrations.

2.2.3 Surface Water

Streams

The primary potential source areas within the Sage Creek basin are Panel A (southern portion), Panels D and E, and the Pole Canyon ODA. The primary potential source areas within the Tygee Creek basin are Panel A (northern portion), and Panels B and C. Concentrations did not exceed surface water quality criteria for any COPCs at the RI stream monitoring locations within the Tygee Creek basin; therefore, the following discussion focuses on surface water contamination in the Sage Creek basin.

The Pole Canyon ODA is distinct from the other Smoky Canyon Mine ODAs because of the cross-valley fill setting and the presence of an underlying shallow alluvial groundwater system associated with Pole Canyon Creek. Prior to implementation of the 2006 NTCRA, Pole Canyon Creek water entered the upstream side of the ODA and then was either lost to Wells Formation bedrock and alluvial deposits beneath the ODA or discharged at the downstream end, or toe, of the ODA. During the relatively dry months from late summer through early spring, most of the creek flow was lost under the ODA. Any creek water that did emerge from the ODA was quickly lost to alluvial deposits before the creek entered Sage Valley. During the fall of very dry years, all Pole Canyon Creek flow was lost underneath the ODA, with no flow discharging from the toe of the ODA. During typical spring runoff (i.e., high-flow) conditions, discharge from the toe of the ODA flowed into Sage Valley where it was still lost to alluvial deposits; occasionally, however, a portion of the creek flowed across Sage Valley and eventually flowed into North Fork Sage Creek and then to Sage Creek. Selenium concentrations in the water discharged at the toe of the ODA typically ranged from 0.5 to 1.5 mg/L, which exceeded the aquatic water quality standard (0.005 mg/L).

Implementation of the 2006 and 2013 NTCRAs has significantly reduced the transport of selenium from the Pole Canyon ODA to the environment. The 2006 NTCRA isolated the ODA from contact with flow in Pole Canyon Creek by conveying creek water around the ODA in a pipeline and discharging the water downstream of the ODA. In addition, storm water that previously flowed onto the ODA is now conveyed to the toe in a control ditch without contacting overburden. The 2013 NTCRA cover system has reduced the amount of water that infiltrates into the surface of the ODA. The significant reduction in water contacting overburden materials has reduced the mass of selenium released from the ODA to the environment.

As described in the Pole Canyon NTCRA 2017 Annual Report (Formation 2018b), since implementation of the 2006 NTCRA, selenium concentrations in water discharging from the toe of the ODA at LP-1 have increased (from 0.5 to 1.5 mg/L before the NTCRA to 3 to 6 mg/L after the NTCRA) because creek water is no longer available to dilute the infiltrated rainfall and snowmelt. However, the magnitude and duration of flow has decreased substantially and toe seep water, if any, infiltrates to the subsurface immediately downstream of the toe and generally does not reach lower Pole Canyon Creek downstream from the bypass pipeline discharge. As a result, most of the selenium mass load associated with toe seep flow is now transported to the underlying alluvial groundwater (and potentially the deeper Wells Formation aquifer) rather than directly to surface water that flows into Sage Valley.

The annual selenium load from the Pole Canyon ODA to the environment is calculated by multiplying the annual volume of water leaving the ODA (via the surface water, alluvial groundwater, and Wells Formation groundwater pathways) by the annual average selenium concentration in surface water or groundwater (Formation 2018b). The estimated annual flow from the ODA to surface water, alluvial groundwater and Wells Formation groundwater is shown in Table 2-2. The water balance model provides estimates for the current condition (i.e., with the NTCRAs) and for a hypothetical scenario where no actions were implemented. In 2017, the NTCRAs were estimated to have reduced water flow from the ODA to surface water by 98%; to alluvial groundwater by 90%; and to Wells Formation groundwater by 98% (Table 2-2). On a mass basis (combining flow estimates and measured selenium concentrations) the NTCRAs were estimated to have resulted in a reduction in selenium load from the ODA to the environment of 94% in 2017 (94% in surface water, 90% to alluvial groundwater and 98% to Wells Formation groundwater) (Table 2-3).

Surface discharge of Wells Formation groundwater at Hoopes Spring and South Fork Sage Creek springs, with flow continuing downstream in lower Sage Creek, is the primary transport pathway for selenium leaving the Site. Water discharging from the springs provides the majority of the flow in lower Sage Creek under all flow conditions and contains selenium at concentrations that exceed the aquatic water quality standard (0.005 mg/L). Selenium concentrations over the past several years at individual spring discharge locations have been as high as 0.134 mg/L at Hoopes Spring location HS in 2015 and 0.099 mg/L at South Fork Sage Creek springs location LSS-SP-N in 2017, although these concentrations have remained relatively constant over this period (Formation 2016d, 2018). Immediately downstream from the springs complex, the highest selenium concentrations in creek water have been 0.106 mg/L (HS-3, downstream of Hoopes Spring) and 0.0278 mg/L (LSS, downstream of South Fork Sage Creek springs) (Formation 2018b).

The selenium load from these springs has been increasing over the past several years as selenium transported from the southern portion of Panel A, the Pole Canyon ODA, Panel D, and Panel E arrives, with recent loads of 3 to 4 pounds per day at Hoopes Spring and 0.7 to 0.8 pounds per day at South Fork Sage Creek springs. The selenium load does not show significant seasonal trends and, therefore, in a given year the relatively constant load results in higher selenium concentrations in immediately downgradient streams (i.e., lower Sage Creek and Crow Creek) during low-flow conditions (late summer, early fall) and lower concentrations in high-flow conditions (spring runoff). As unaffected water enters the stream system from groundwater discharge and surface water from other creeks (e.g., Crow Creek upstream of the confluence with

Sage Creek), selenium concentrations decrease, and the selenium load remains relatively constant downstream of the inflow from the springs complex. However, selenium concentrations are still above the aquatic water quality standard (0.005 mg/L) at the Wyoming border during low-flow conditions.

For surface water in streams, exceedances of surface water benchmarks for non-selenium COPCs was observed only for cadmium at several of the surface water monitoring locations. However, these exceedances were generally also associated with selenium exceedances. For springs at the Site (Hoopes Spring and South Fork Sage Creek springs), selenium was the only COPC that exceeded benchmarks or criteria.

Seeps and Detention Basins

Surface water sampling at the Site included surface expressions of seepage from the ODAs and detention basins that collect seepage and runoff from the pits and external ODA. Runoff from roadways is addressed under active mine operations which includes management of runoff and receiving detention basins. Storm water runoff is addressed under the Smoky Canyon Mine Storm Water Pollution Prevention Plan (SWPPP).

Flow rates at some seeps can vary substantially seasonally, and at some locations surface seeps are only present in the spring. Evaluation of data collected before and/or during the RI showed elevated selenium concentrations in surface water features at five overburden seep areas (AS-2, DS-7, DS-10, ES-4, and ES-5; note that only DS-7 now flows with any regularity) and the associated detention basin waters downgradient from those seeps (AP-2, DP-7, DP-10, EP-4, and EP-5). Of the seeps currently flowing, DS-7 and LP-1 have the highest selenium concentrations. Detention basins receiving seep water with elevated selenium concentrations from the overburden areas also exhibit the highest selenium concentrations. Where selenium concentrations are elevated, other COPCs including arsenic are also elevated. Although elevated, the basin-water selenium concentrations are lower than in the nearby seep waters.

In addition to arsenic, exceedances of benchmarks for other non-selenium COPCs were observed for cadmium, chromium, nickel, vanadium, and zinc. However, these exceedances were not as consistent as those identified for selenium in seeps and detention basins and were typically co-located with elevated selenium concentrations.

The transport of solids by erosion and sediment transport is limited by the coarse texture of the overburden and the best management practices (BMPs) (e.g., soil cover, revegetation, etc.) that have been implemented during mining operations to control runoff and erosion from the ODAs. To the extent that COPC transport takes place by erosion of the source materials via surface water runoff from ODAs, those surface pathways end at the detention basins and do not extend to native soils or sediments or to Site streams. With the exception of a few isolated events where local failures of overburden fill resulted in overtopping of detention basins, overburden erosion and transport to native soils or sediments in stream drainages has not occurred.

2.2.4 Stream Sediment

Potential sediment transport pathways from source areas to local surface water drainages were evaluated in the RI by comparing selenium concentrations from upstream to downstream monitoring locations in streams. As described above, runoff from roadways is addressed under active mine operations and storm water runoff is addressed under the Smoky Canyon Mine SWPPP. For stream sediments, selenium exceeded the screening-level benchmark for sediment (2 mg/kg) at the following locations, which are all downstream from mine-disturbance areas: lower Pole Canyon Creek (LP-PD), the stream downstream from Hoopes Spring (HS-3), North Fork Sage Creek in northern Sage Valley (NSV-6), and lower Sage Creek (LSV-2C, LSV-3, LSV-4).

Elevated concentrations of selenium in stream sediments in the locations noted above are a result of selenium transport in surface water (from groundwater discharging at Hoopes Spring and South Fork Sage Creek springs) and sorption of the dissolved selenium to stream sediments. The presence of elevated selenium and other COPC concentrations in lower Pole Canyon Creek sediment samples is also due to the deposition of overburden slope materials into the creek during a past slope failure at the toe of the ODA in spring 1996. The slope has since been stabilized, but residual sediments remain in the creek bed below the ODA. Except for Pole Canyon Creek immediately downstream of the Pole Canyon ODA, there are no surface transport pathways for sediment from source areas to streams. Sediment that is eroded in storm water runoff from the ODAs is collected in detention basins and therefore prevented from entering streams.

2.2.5 Terrestrial and Aquatic Biota

Terrestrial and aquatic biota data were collected during the RI for characterization of selenium in fish tissues, benthic invertebrate tissues, aquatic vegetation, small mammals, and terrestrial invertebrates.

Terrestrial invertebrate and small mammal tissue selenium concentrations from ODAs with minimal or no cover material and from certain overburden seep areas are elevated in comparison to samples from adjacent areas. The elevated concentrations are related to the abiotic selenium levels and may indicate bioaccumulation of selenium in the food chain. This is particularly apparent in Panel A, Panel D, and the Pole Canyon ODA where selenium concentrations in both terrestrial invertebrates and small mammals were elevated relative to the areas of the Site where selenium concentrations in soil are lower (i.e., Panel E, northern Sage Valley, and the samples collected from areas adjacent to mine disturbances). Other chemicals with elevated concentrations that may pose potentially unacceptable risks to terrestrial biota included cadmium, chromium, copper, lead, manganese, molybdenum, vanadium, and zinc. However, the risks from these COPCs were lower than from selenium and were generally co-located with areas of selenium risk.

Copper concentrations in small mammal tissue collected during the RI ranged from 11.9 to 3,900 mg/kg (Formation 2014c), and concentrations ranged from 10.7 to 936 mg/kg in follow-up samples collected in 2016 (Formation 2018a). After outliers (concentrations greater than 1,100 mg/kg) and results greater than the maximum tissue concentration observed in the literature (622 mg/kg) were removed, the range of copper concentrations in small mammals was lower (10.7 to 619 mg/kg). Based on copper concentrations in soil and other tissue samples collected from the same areas, concentrations measured in small mammals collected from other southeast Idaho phosphate mine sites, and concentrations reported in the literature for copper-contaminated sites, elevated copper concentrations at Smoky were considered anomalous (Formation 2018a). Copper contamination is not associated with phosphate mining and copper was not identified in the Smoky Canyon Mine RI at elevated concentrations in soils. Although the source of copper to small mammals remains uncertain, copper concentrations are considered anomalous.

Elevated selenium concentrations in fish tissue immediately downstream from Hoopes Spring and in lower Sage Creek appear to be directly correlated with surface water concentrations in these stream reaches. Dietary sources may also contribute, as selenium concentrations in benthic macroinvertebrates at these locations were slightly elevated with respect to background. Selenium concentrations in macrophytes and periphyton also followed a similar pattern, with the highest selenium concentrations in lower Pole Canyon Creek.

2.3 Fate and Transport Summary

As identified in the RI, pathways for transport of selenium identified at the Site are:

- Release from backfilled pits and external ODAs and transport downward to the underlying Wells Formation groundwater at the Site. Transport in the groundwater and discharge to surface water via springs and, when pumping, discharge at the Industrial Well in the northern portion of the Site.
- Release from the Pole Canyon ODA to alluvial groundwater beneath the Pole Canyon Creek channel. This alluvial groundwater continues into northern Sage Valley and likely discharges to downgradient surface water, but the associated selenium load addition is too small to detect.
- Surface water flow through the base of the Pole Canyon ODA and into Pole Canyon Creek prior to implementation of the 2006 NTCRA and during an isolated event in 2011 when the bypass pipeline was operated at less than design capacity. Surface water runoff from other ODAs (i.e., storm water runoff and seeps from ODA toes) is contained in ponds and does not reach Site streams via the surface pathway.
- Sediment transport from ODAs primarily during active mining and immediately afterwards (before reclamation). Sediment is contained in storm water detention basins and does not

reach Site streams. The exception is Pole Canyon ODA where sediment was transported to the Pole Canyon Creek channel, primarily by a slope failure in spring 1996.

- Direct uptake by plants growing on overburden.

During scoping of the RI, as summarized in the RI/FS Work Plan (Formation 2011a), the wind dispersion and air deposition potential pathway was identified as insignificant at the Site based on findings of the SI (NewFields 2005). Therefore, this potential pathway was not addressed in the FS.

2.4 Conceptual Model

CSM diagrams for human, ecological, and livestock receptors are presented in the Site-specific risk assessment reports (Figure 4-1 in SSHRA [Formation 2015a], Figure 2-11 in SSERA [Formation 2015b], and Figure 3-1 in SSLRA [Formation 2016a], respectively). Information on contaminant sources, migration routes, exposure pathways, and receptors were used to develop an understanding of the Site and to evaluate potential risks.

2.4.1 Contaminant Sources

Overburden disposed in backfilled mine pits and external ODAs is the source of selenium and other COPCs to the environment. Overburden is removed during active mining to access the underlying phosphate ore. The primary sources of selenium within the overburden are the sulfides and organic matter present in the mudstone and center waste shale from the Meade Peak Member of the Phosphoria Formation. The source areas of the Site include the backfilled mine pits and external ODAs of Panels A through E.

The release of selenium from overburden materials occurs by (1) interaction with infiltrating water/leaching and (2) weathering of overburden. Dissolution of soluble solids and release of associated selenium to infiltrating water represents a relatively short-term release mechanism that takes place primarily during overburden handling and initial disposal. Weathering operates by oxidation of minerals or organic matter to release selenium. Oxidation processes may begin as soon as overburden is excavated and continue in the final disposal setting.

2.4.2 Migration Routes

Pathways for migration of selenium from source areas to groundwater and surface water are described below.

Groundwater

Groundwater pathways for transport of selenium include (1) transport by alluvial groundwater and (2) transport by Wells Formation groundwater.

A valley-fill alluvial groundwater system exists in Sage Valley. The water table in this system is typically less than 30 feet below the ground surface and, at some locations, is intercepted seasonally by Sage Creek. The valley system is connected with shallow alluvial deposits at the mouths of the tributary drainages, and specifically is affected by transport of selenium from the alluvial system underlying and immediately downgradient of the Pole Canyon ODA. The alluvial groundwater system in Pole Canyon is connected to the Wells Formation aquifer; however, the Sage Valley alluvial groundwater flow system is isolated from the Wells Formation by the West Sage Valley Branch Fault that parallels the western side of Sage Valley. In essence, the valley alluvial system has the configuration of a large basin, with flow contributions coming primarily from tributaries along the west side of the valley.

Groundwater flow in the upper Wells Formation aquifer is controlled by the combined effects of the West Sage Valley Branch Fault, which is a barrier to flow to the east, and the discharge zone created by the springs complex to which local and regional Wells Formation groundwater ultimately flows. Together, these springs discharge Wells Formation groundwater in excess of 10 cubic feet per second (cfs) to the Sage Creek drainage; the spring discharge comprises the majority of flow in the lower Sage Creek drainage under all flow conditions. In the north end of the Site, groundwater flow paths within the Wells Formation are also influenced by pumping at the Industrial Well, which generates a large area of hydraulic influence when operated at typically high pumping rates.

As part of the RI, analytical and numerical models were developed to characterize the transport of selenium in groundwater in the Wells Formation aquifer in the southern and northern portions of the Site. An analytical model was developed for the southern groundwater flow system (south-end model), to evaluate the relative contribution from source areas to the selenium mass load discharged at the springs complex. An analytical model and numerical models were also developed for the northern groundwater flow system (north-end models) to estimate potential groundwater concentrations at the northern lease boundary. The models provide a line of evidence in evaluation of the dynamic nature of varying historical Site conditions that have influenced selenium transport over time.

The RI (Formation 2014c) states that the specific objectives of the models were as follows:

- Identify the relative selenium contribution to the springs complex from each mine panel on a year-by-year basis and estimate the future contributions based on past, current, and future reclamation activities or removal actions.
- Estimate potential selenium impacts at the northern lease boundary based on past, current, and future reclamation activities or removal actions.
- Account for Site conditions that change with time due to disturbance and reclamation activities.

The results of the modeling are reported in Appendix H of the RI Report (Formation 2014c). The key findings with respect to the identification of remedial alternatives are summarized here. In the south end of the Site, Wells Formation groundwater discharges at the springs complex. The models developed for the RI estimate selenium loading to Wells Formation groundwater resulting from leaching from the seleniferous overburden by infiltrating precipitation and by storm water run-off where detention basins occur over seleniferous backfill material. This loading is shown as the black dotted line on Figure 2-5. The model is currently being updated for the FS.

In general, the maximum selenium loading from an ODA to groundwater occurs during active mining and prior to completion of reclamation. Once an area is reclaimed, selenium loading to groundwater reduces over time due to the reduction of releases from the overburden (i.e., the source term characteristics). For example, mining at Panel D began in 1993 and continued through 1998. Reclamation at Panel D began in 1996 and was completed in 2002. Mining at Panel E occurred in 1998 through 2006. Portions of Panel E remained open through 2011 to receive backfill from Panel F. Most of the reclamation was competed in 2013. Each of these mine panels have the similar characteristics of peak loading during active mining and reduced loading after reclamation. The relative magnitude of loading after reclamation is affected by the reclamation type; infiltration-reduction covers result in lower levels of loading.

The Pole Canyon ODA, which received seleniferous backfill from 1985 through 1990, is a unique setting because it is a cross-valley fill with surface water flowing through the ODA. Prior to backfilling, a coarse-grained chert material was placed at the base of the ODA to create of a zone of higher hydraulic conductivity through which Pole Canyon Creek flowed. Selenium was mobilized from the overburden by the creek water as it passed through the ODA (1985 through 2007). The first NTCRA at the Pole Canyon ODA included a pipeline to divert a portion of the Pole Canyon Creek stream flow around the ODA, an infiltration basin that directs the remaining clean Pole Canyon Creek flow to the Wells Formation aquifer upstream of the ODA, and a channel that controls run-on to the Pole Canyon ODA. These actions were completed in 2008 and significantly reduced the mobilization of selenium and subsequent loading to groundwater (see Figure 2-5). The second NTCRA included storm water controls and a Dinwoody/Chert cover system completed in 2015, further reducing selenium loading to groundwater.

The estimated loads from each panel to groundwater are transported to the springs complex based on the travel time as shown by the blue lines on Figure 2-5. The loading from panels that are farther away (i.e., Panel A) take longer to reach the springs than the loads that are closer (i.e., Panel E) The loads are then added to estimate the total selenium load at the springs complex over time, as shown on Figure 2-6. Overall, the RI modeling effort found that selenium released during active mining began to arrive at the springs complex in the late 1990s and was predicted to peak in the 2015/2016-time frame (Appendix H, Formation 2014c). Because mining began farther north and has progressed south, these arrival signatures have overlapped (Figure 2-6). In each case, the estimated loading curves from a given panel peak due to the effects of active mining and then reduce to a steady-state loading reflecting the post-mining/reclaimed condition. For the Pole Canyon ODA, diversion of Pole Canyon Creek around the ODA starting in 2007 and completion of the NTCRA cover in 2015 are predicted to begin reducing loading at the springs complex in the late 2020s. As noted previously, the modeling is being updated to reflect the latest understanding of the Site for use in the FS.

The predicted loading estimate from key areas to the springs complex in 2050 (i.e., after the effect of all completed actions is realized) is due to infiltration into the ODAs and subsequent release and transport of selenium shown in Table 2-4. These values show the relative importance of each source area to selenium loading and can be used to identify where remedial actions might be needed to meet RAOs. As shown, most of the loads are predicted to come from the Panel A area and Panel D area. The Panel A and D areas have relatively less protective covers than the more recent covers installed on portions of Panel E and the Pole Canyon ODA, and therefore, these will be the focus of the evaluation of remedial alternatives in this FS.

North-end modeling analyses were conducted to evaluate two issues regarding the influence of mining activity on selenium concentrations in the Wells Formation groundwater:

- Extent of containment provided by pumping at the Industrial Well (GW-IW).
- Potential north-end source area influence on groundwater not captured by the Industrial Well.

An analytical model and a numerical model were developed to address these issues. Both north-end models used results of the GIS-based source term model to account for the spatial and temporal distribution for multiple source areas and associated selenium loading to the Wells Formation aquifer.

Assessment of containment provided by pumping at the Industrial Well resulted in a structural influence (e.g. faulting) capture zone assumption. Figure 2-7 illustrates the capture zone and seleniferous backfill areas inside the capture zone. The applicability of the structural control assumption suggests that sources in Panels A and C are captured by the Industrial Well.

As noted previously, the modeling is being updated to reflect the latest understanding of the Site for use in the FS. The conceptual model for north end groundwater, in particular has changed significantly since the RI This updated model will be presented in an appendix to FSTM#2 and used to evaluate remedial alternatives in the detailed analysis.

Surface Water

Surface water pathways for transport of selenium include (1) transport by runoff from ODAs, (2) transport by seep flow from ODAs, and (3) transport by stream flow.

Based on the RI (Formation 2014c), there is no evidence that storm water runoff transports selenium to surface waters in the drainages that cross mining-disturbed areas. However, runoff from ODAs to detention basins and subsequent infiltration to Wells Formation groundwater is a potential transport pathway.

The seeps represent a transport pathway for selenium from the ODAs to soil below ODA seeps and, for DS-7 and ES-3, to detention basins below these ODA seeps. At the seeps where flow was present during RI data collection (LP-1, DS-7, and ES-3 for only a portion of the time), ongoing infiltration of seep water into the subsurface also represents a potential transport pathway to groundwater. The highest potential selenium loading to groundwater is associated with seeps LP-1 and DS-7 which have the highest selenium concentrations and mass loading rates. These two seeps have the potential to infiltrate into the underlying deep Wells Formation aquifer. Seep LP-1 also infiltrates into the shallow alluvial groundwater flow system that overlies the Wells Formation.

The RI (Formation 2014c) indicated that Smoky Creek, Pole Canyon Creek, Sage Creek, and South Fork Sage Creek have not received runoff from mine-disturbance areas. However, the Wells Formation aquifer discharges groundwater to surface water at Hoopes Spring and South Fork Sage Creek springs; the selenium mass load discharging at the springs complex originates entirely from Wells Formation groundwater. The flow from Hoopes Spring continues downstream into Sage Creek upstream of its confluence with South Fork Sage Creek. The flow from South Fork Sage Creek springs enters South Fork Sage Creek near the groundwater discharge locations.

2.4.3 Exposure Pathways

The risk assessments evaluated numerous exposure pathways and receptors.

Potentially complete significant human exposure pathways are:

- Ingestion of surface water and groundwater for domestic drinking water supply

- Ingestion of livestock that grazed at the Site (beef)

Potentially complete significant exposure pathways for terrestrial ecological receptors are:

- Incidental ingestion of overburden material and soil
- Ingestion of small mammals
- Ingestion of terrestrial plants growing on overburden material and soil

Potentially complete significant exposure pathways for riparian and aquatic receptors are:

- Ingestion of surface water and incidental ingestion of soil (riparian only) and sediment (fish and riparian receptors)
- Ingestion of aquatic plants, periphyton, zooplankton, and benthic invertebrates (fish and riparian receptors)
- Ingestion of fish and amphibians (riparian receptors)

Potentially complete significant exposure pathways for livestock are:

- Ingestion of terrestrial plants as forage
- Ingestion of surface water as drinking water
- Ingestion of groundwater would represent an exposure risk only if wells are developed for stock watering.

2.4.4 Potential Receptors

The risk assessments identified the following potential receptors that had the potential to be exposed to selenium and other COPCs at levels that could present an unacceptable risk:

<u>Human</u>: Current and potential future seasonal ranchers and Native Americans, and potential future recreational campers and hypothetical residents (assumed only on private lands).

<u>Ecological</u>: Terrestrial vegetation and terrestrial and riparian wildlife such as mice, vole (riparian only), rabbits, mink (riparian only), raccoons (riparian only), ducks (riparian), birds, coyotes, and mule deer. Aquatic receptors are fish, amphibians, and benthic invertebrates in lower Sage Creek.

<u>Livestock</u>: Sheep. Cattle and horses may also potentially be exposed.

2.5 Risk Assessments

The primary objectives of the SSHHRA (Formation 2015a) and SSERA (Formation 2015b) were to evaluate the possible human health and ecological risks associated with potential exposure to environmental media at the Site to help determine the need for remedial action. The primary objective of the SSLRA (Formation 2016a) was to evaluate potential livestock risks associated with potential exposure to environmental media to provide the regulatory agencies with the information necessary to make informed decisions regarding range management.

2.5.1 Human Receptors

Arsenic was the only chemical for which cancer risk estimates exceeded the target cancer risk goal of 1E-05, and arsenic was identified as a human health chemical of concern (HH COC) for the seasonal rancher, recreational camper, Native American, and hypothetical resident receptor scenarios, with contributions from several environmental media (Formation 2015a).

<u>Seasonal Rancher</u>

Potentially unacceptable current and future risks are from:

- Beef – arsenic

Ingestion of beef was the primary contributor of cancer risk for the seasonal rancher and arsenic was the only chemical for which cancer risk estimates exceeded the target cancer risk goal of 1E-05. The exposure point concentration (EPC) for beef was modeled based on Site-wide arsenic concentrations in samples of soil, forage plants, and/or water. Concentrations of arsenic in vegetation are elevated in areas of the Site that have overburden at the surface, and livestock may be exposed if they graze in those areas.

Thallium exposures exceeded the USEPA non-cancer threshold for ingestion of beef by the seasonal rancher, with elevated thallium concentrations in overburden within the mine area influencing the calculated uptake. However, data from regional studies suggest that thallium concentrations in soils at the Site are within the range of natural background concentrations. Therefore, risks from thallium would be considered only within the context of natural background exposure along with the considerable uncertainty in the uptake coefficient used to model beef concentrations.

<u>Recreational Camper and Native American</u>

Potentially unacceptable future (recreational camper) and current and future (Native American) risks are from:

- Surface water (domestic drinking water supply) – arsenic

Surface water locations associated with seeps (DS-7 and LP-1) and detention basins (DP-7 and EP-2) contain arsenic concentrations that exceed the Idaho drinking water standard (0.01 mg/L). These locations contributed to exposure and lifetime cancer risks in excess of 1E-05. Arsenic concentrations at all other surface water and groundwater sampling locations are lower than the drinking water standard.

<u>Hypothetical Resident</u>

Potentially unacceptable future risks are from:

- Groundwater (domestic drinking water supply) – selenium and arsenic

Although land use and population statistics indicate that the Site is unlikely to convert to residential use, the hypothetical resident receptor was assessed for private lands in accordance with Forest Service guidance (USFS 2013b). Potentially unacceptable risks (cancer risks in excess of 1E-05) from selenium and arsenic were estimated for the hypothetical resident scenario in which groundwater is used for domestic drinking water supply. Selenium concentrations in groundwater exceeded the Idaho drinking water standard (0.05 mg/L) at several wells immediately downgradient of the Pole Canyon ODA, but concentrations in groundwater from all other locations were lower than the drinking water standard. These wells also contained arsenic concentrations that exceeded the Idaho drinking water standard (0.01 mg/L). Both locations are immediately downgradient of the Pole Canyon ODA and are known to be affected by past infiltration of water into the ODA, and downgradient transport in alluvial and Wells Formation groundwater.

2.5.2 Ecological Receptors

Selenium is the primary risk driver for both current and future aquatic and terrestrial biota (Formation 2015b). Conclusions for aquatic receptors are presented by media type to reflect the risk analysis organization and regulatory framework for aquatic environments. Terrestrial risk analysis is based on ingestion of ecological chemicals of concern (ECOCs) from multiple exposure media within each habitat.

<u>Aquatic</u>

Potentially unacceptable current and future risks for aquatic receptors are from:

- Surface water – selenium
- Fish tissue – selenium

Selenium is the primary risk driver in surface waters across several drainages. Other ECOCs that exceeded Toxicity Reference Values (TRVs) primarily in surface waters included aluminum, arsenic, cadmium, iron, nickel, and zinc (Formation 2015b). Where elevated, these ECOCs do not likely represent unacceptable risk because of the very limited potential for exposure (e.g., seeps or ephemeral habitats) of receptors to these environments. Locations where elevated selenium concentrations exist and pose risk to aquatic receptors correspond to areas of known inputs such as Hoopes Spring and South Fork Sage Creek and their downstream receiving waters, and Pole Canyon Creek.

Selenium concentrations in surface water from Pole Canyon Creek, North Fork Sage Creek, Hoopes Spring, South Fork Sage Creek, Lower Sage Creek, and Crow Creek exceeded the Idaho surface water quality criterion (5 µg/L). However, the current state of the science indicates that selenium concentrations in egg/ovary tissues from fish and other aquatic organisms provide the best measure of effects for aquatic life. To date, egg/ovary data have largely been compiled for fish species which have thus far been demonstrated to be suitably sensitive. Therefore, fish tissue data should be used to assess risk to aquatic receptors rather than surface water data.

Selenium in fish tissue is the most reliable measure of exposure and potential risk for fish and other aquatic receptors. Whole body selenium fish tissue concentrations downstream of major sources exceeded the USEPA-derived National Criterion (8.5 mg/kg dry weight [dw]), the brown trout threshold derived by USEPA (13.2 mg/kg dw) and the Simplot-derived threshold for brown trout (14.14 mg/kg dw) at Hoopes Spring, lower Sage Creek, and lower Crow Creek. Overall, fish tissue from Crow Creek and South Fork Sage Creek do not exceed these thresholds. The physical habitat at Pole Canyon Creek (LP-PD) and North Fork Sage Creek (NSV-6) does not support any fish, and benthic tissue data indicated that selenium bioaccumulation in those tissues was acceptable. Pole Canyon Creek at the LP-1 seep poses unacceptable risks to higher trophic level organisms that may obtain food or water from that location. Other ECOCs that were elevated in fish tissues included aluminum and essential micronutrients copper, iron, and zinc. The contributions of background to tissue concentrations, as well as the reliability of the TRVs used to assess potential risks, were discussed in the Uncertainty Analysis of the SSERA (Formation 2015b).

Selenium in sediments from Hoopes Spring (HS-3) and North Fork Sage Creek (at NSV-6), and at Pole Canyon Creek (LP-PD, LPT-1, LPT-2, and LPT-3) exceeded the sediment TRV. However, the TRVs for selenium in sediments are not based on effects to benthic invertebrates, but rather as potential bioaccumulation effects to organisms that consume those benthic invertebrates. Literature-derived tissue TRVs for benthic invertebrates, compared to concentrations measured for invertebrate tissues collected from across the Site, indicate selenium in invertebrate tissues potentially poses a risk only in lower Sage Creek. Although sediment in upper Sage Creek (upstream of inflow from Hoopes Spring) was identified as posing a risk, it was clearly a function of a single location (SV-1, an irrigation ditch) where consistently higher selenium concentrations were found. However, as mentioned above, the pathway for exposure is incomplete, as connectivity to downstream waterbodies is limited and inconsistent. In addition to selenium in sediments, other ECOCs that were elevated above TRVs included barium, cadmium, chromium, nickel, manganese, silver, and zinc.

The concentration of selenium in biotic and abiotic media exceeds TRVs for aquatic receptors at certain locations (Formation 2015b). ECOCs at the LP-1 seep and at SV-1 pose unacceptable risks; however, whether these concentrations represent significant ecological risk is often a function of habitat and connectivity of surface water to source areas or accessibility by terrestrial organisms. As discussed in the SSERA, the LP-1 seep at the toe of the Pole Canyon ODA is isolated and typically disconnected from the main stream due to installation of the Pole Canyon Creek bypass pipeline (under the 2006 NTCRA). Therefore, the potential for exposure to these concentrations is extremely limited for aquatic ecological receptors. For LSV-1, which is located in an irrigation ditch near Sage Creek, downgradient of detention basin DP-2, flow is ephemeral at best and no appreciable aquatic habitat is present. Because permanent aquatic habitat is limited or absent, no adverse effects on aquatic populations is likely due to the lack of exposure.

<u>Terrestrial Upland</u>

Potentially unacceptable current and future risks to terrestrial upland receptors are from:

- Food/Soil/Surface Water (Panel A Area 2, Panel D North and South) – selenium

Selenium in soils, vegetation, and terrestrial invertebrates and small mammals is the primary risk driver at the Site (Formation 2015b). Other chemicals identified as posing potentially unacceptable risks in the Tier 1/Tier 2 analysis included cadmium, copper, lead, vanadium, and zinc; however, the risks from these ECOCs were lower than from selenium and were generally co-located with areas of selenium risk.

Elevated concentrations of ECOCs were observed primarily in mined areas with either no cover (i.e., direct revegetation of overburden) or topsoil-only reclamation and elevated concentrations of ECOCs in soils corresponded with higher exposure and risks. Risks are highest in Panel A Area 2, Panel D North and South, and on the Pole Canyon ODA (prior to construction of the cover system in 2015 under the 2013 NTCRA) which represent areas where exposure to selenium-bearing overburden materials is expected to be highest. Exposure and risks were considerably lower for northern Sage Valley, Panel A Area 1, and Panel E (Figure 2-8). Risks were lowest in the areas with a Dinwoody/Chert cover and highest in the areas with no cover.

Based on the SSERA conclusions, risks to sub-populations of small mammal and bird receptors inhabiting Panel A Area 2, and Panel D North and South could not be ruled out using the available data. Exposure to the terrestrial receptors and potential risk is elevated compared to the surrounding areas, but it is unknown whether any actual effects are occurring to the populations inhabiting those areas. No data are currently available to address the presence or absence of population-level effects from selenium as predicted in the SSERA (Formation 2015b). While no detailed population studies were conducted in those areas, small mammal sampling was successful in both 2010 and 2016 suggesting the presence of a functioning small mammal community. In 2010, a total of seven species of small mammals, dominated by deer mice

(*Peromyscus maniculatus*) and, to a lesser extent, three vole species (meadow, long-tailed, and montane), were captured in the upland areas of the mine and in Sage Valley. Both male and female deer mice and voles were captured. For the more abundant deer mice, representative animals from the juvenile, sub-adult, and reproductive adult age classes were captured. In limited sampling during 2016, both deer mice and meadow voles were captured that included age classes of both species ranging from juvenile to reproductive adults. These data suggest that an adequate source of food and habitat is present on the ODAs to support a small mammal community containing all age classes of animals. The presence of a small mammal community does not preclude the SSERA conclusions, but it does represent an uncertainty regarding the predictive ability of the risk-models used in predicting population-level effects to the small mammal receptor.

Riparian

Potentially unacceptable current and future risks to riparian receptors are from:

- Food/Soil/Sediment/Surface Water (seeps and springs) – selenium

Similar to the upland areas of the Site, selenium is the primary risk driver; however, other ECOCs were identified for riparian receptors including cadmium, chromium, copper, lead, manganese, molybdenum, vanadium, and zinc (Formation 2015b). As indicated for the upland areas, exposure and risk associated with the non-selenium ECOCs is lower than risks predicted from selenium. Elevated selenium concentrations in semi-aquatic habitats at the Site were limited to a few sampling locations. Selenium exposures were much higher than elsewhere at seeps DS-7 (east of Panel D) and ES-4 (east of Panel E), as well as riparian location LP-PD (Pole Canyon). Risk was lowest at seep ES-3 (east of Panel E).

2.5.3 Livestock Receptors

Potentially unacceptable current and future risks to livestock are from:

- Vegetation – selenium
- Surface water – selenium

Selenium is the primary risk driver for livestock (Formation 2016a). While exposure to several other chemicals of concern (COCs) (barium, iron, manganese, and molybdenum) exceeded risk benchmarks in some areas, the elevated concentrations coincided with selenium exposures in most cases. Exposure to these other COCs was described as likely representing background conditions. Potentially unacceptable risks to livestock from selenium were calculated for vegetation, surface water, and groundwater (if used for stock watering in the future).

The greatest potential for adverse effects from vegetation is from sampling locations in mine-disturbance areas in the Pole Draney and Sage Valley grazing allotments (Figure 2-9) where selenium concentrations exceeded the acute TRV (Formation 2016a). Of the five grazing allotments that overlap the Site, only the Sage Valley Allotment contained average concentrations that exceeded the chronic TRV. Site-specific risks from selenium in surface water are restricted to seep and spring locations immediately downgradient of the Pole Canyon ODA and Panel D; however, these seep areas are typically fenced to prevent access. Overall chronic and acute risks from selenium are unacceptable primarily due to surface water and vegetation associated with backfilled pits and ODAs in the Sage Valley and Pole Draney grazing allotments. Exposure in other allotments was within acceptable levels.

TABLE 2-1. Reclamation Areas and Cover Types

Mine Panel Area	Subarea[1]	Cover Type	Area (acres)
Panel A	Area 1 - Backfilled Pits	Topsoil over Dinwoody and Chert	60
	Area 1 - External ODA	Topsoil over Dinwoody and Chert	20
	Area 2 - Backfilled Pits	Topsoil Only	115
	Area 2 - External ODA	Direct Revegetation, Topsoil Only	75
Panel C	Backfilled Pit	Topsoil over Dinwoody and Chert	105
Panel D	North - Backfilled Pits	Topsoil Only	95
	North - External ODA	Direct Revegetation	65
	South - Backfilled Pits	Topsoil over Chert	110
Panel E	Area 1 - Backfilled Pits	Topsoil over Chert	60
	Area 1 - External ODA	Topsoil over Chert	70
	Area 2 - Backfilled Pits	Topsoil over Dinwoody and Chert	150
	Pit E-0 - Backfilled Pits	Deep Dinwoody Store and Release [2]	60
Pole Canyon ODA	Pole Canyon ODA	Dinwoody over Chert [3]	130

Notes:

1 - Subareas are identified based on RI sampling areas (see RI Report, Formation 2014c), with further delineations of backfilled pits, external ODAs, and reclaimed areas (outside of RI sampling areas) based on mine reclamation data.

2 - A Deep Dinwoody Store and Release cover system was constructed on Pits E-0n and E-0s in 2014. These pits were open during soil sampling for the RI.

3 - A Dinwoody Over Chert cover was constructed on the Pole Canyon ODA in 2015 under a Non-Time-Critical Removal Action (NTCRA). During RI data collection and reporting (see RI Report, Formation 2014c), the cover types on the Pole Canyon ODA were Direct Revegetation and Topsoil Only.

TABLE 2-2. 2017 Pole Canyon ODA Water-Balance Model Outflow Summary

	Without NTCRAs (acre-feet)	With NTCRAs (acre-feet)	Estimated Reduction (percent)
Outflow			
Surface water discharge to lower Pole Canyon (measured at LP-1)	1087	20	98%
Average annual flow to alluvial groundwater	65	7	90%
Average annual flow to Wells Formation groundwater	676	16	98%
Total	**1828**	**43**	**98%**

TABLE 2-3. 2017 Pole Canyon ODA Mass-Balance Model Summary

	Without NTCRAs	With NTCRAs	Estimated Reduction (percent)
Annual Selenium Mass Transport			
Annual average selenium concentration in outflow surface water	1.1 mg/L	3.7 mg/L	---
Annual average selenium concentration in seepage to groundwater	0.44 mg/L	0.44 mg/L	---
Average annual load to surface water in lower Pole Canyon Creek	3249 lbs	206 lbs	94%
Average annual load to alluvial groundwater	78 lbs	8 lbs	90%
Average annual load to Wells Formation groundwater	813 lbs	19 lbs	98%
Total	**4140 lbs**	**233 lbs**	**94%**

TABLE 2-4. RI Model – Predicted Selenium Loading from Each Source Area to Springs Complex in 2050

Mine Feature	Area (acres)	Predicted Selenium Load to Springs in 2050 (No Further Action) (lbs/year)[3]	Percent of Total Load to Springs
		Direct Infiltration	
Panel A Area 2	180	130	41%
Pole Canyon ODA	130 [1]	16	5%
Panel D	250	104	33%
Panel E	340 [2]	68	21%
Total	900	**318**	**100%**

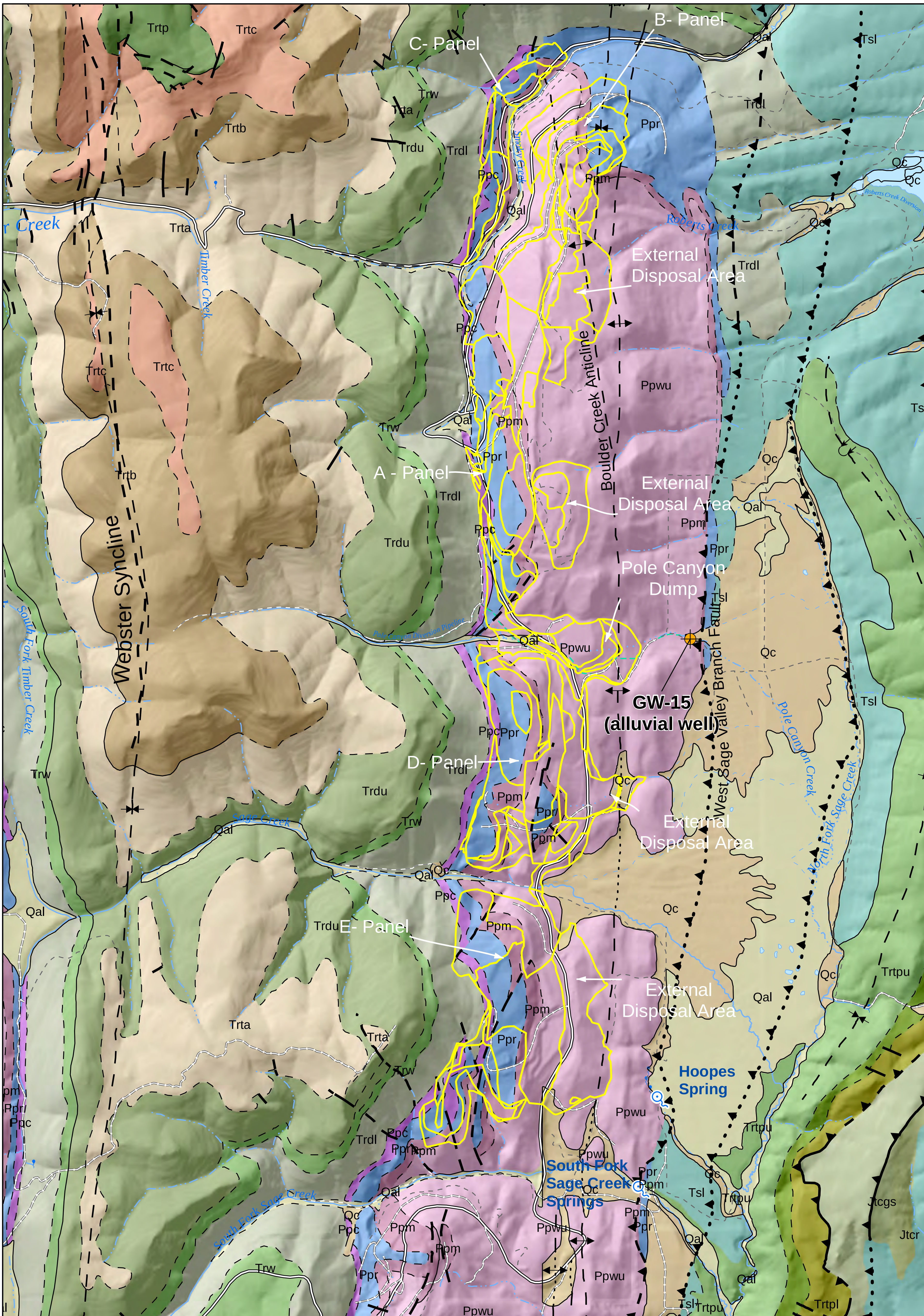
Notes:

lbs/year - pounds per year

1 - Area covered under the 2013 NTCRA.

2 - Area where seleniferous materials are present.

3 - Values are from the RI model. The model is being revised for the FS and updated estimates will be presented in FSTM#2.



Legend

Geologic Features

Contact (Dashed where inferred, dotted where buried)

Normal Fault (Dashed where inferred, dotted where buried)

Thrust Fault (Dashed where inferred, dotted where buried)

Syncline Axis

Anticline Axis

Hydrology

Perennial Stream

Intermittent Stream

Mine Features

Areas of Mine Disturbance

Geology:
Geology of the Sage Valley Quadrangle, Idaho-Wyoming. John L. Conner, BYU, 1980
Geology of the Stewart Flat Quadrangle, Caribou County, Idaho. Kathleen M. Montgomery and T. M. Cheney, USGS, 1967

Topography:
2011 aerial survey (shown as hillshade).

Montgomery & Cheney (1967) | Conner (1980)

See Figure 2.3-2 for Explanation of Geologic Map Units.

0 1,500 3,000
Feet
N

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SMOKY CANYON MINE RI/FS
FEASIBILITY STUDY TECH MEMO #1

FIGURE 2-1

GEOLOGIC MAP OF SMOKY CANYON MINE AND VICINITY

DATE: JULY 2018

BY: CRL | FOR: ACK

FORMATION ENVIRONMENTAL

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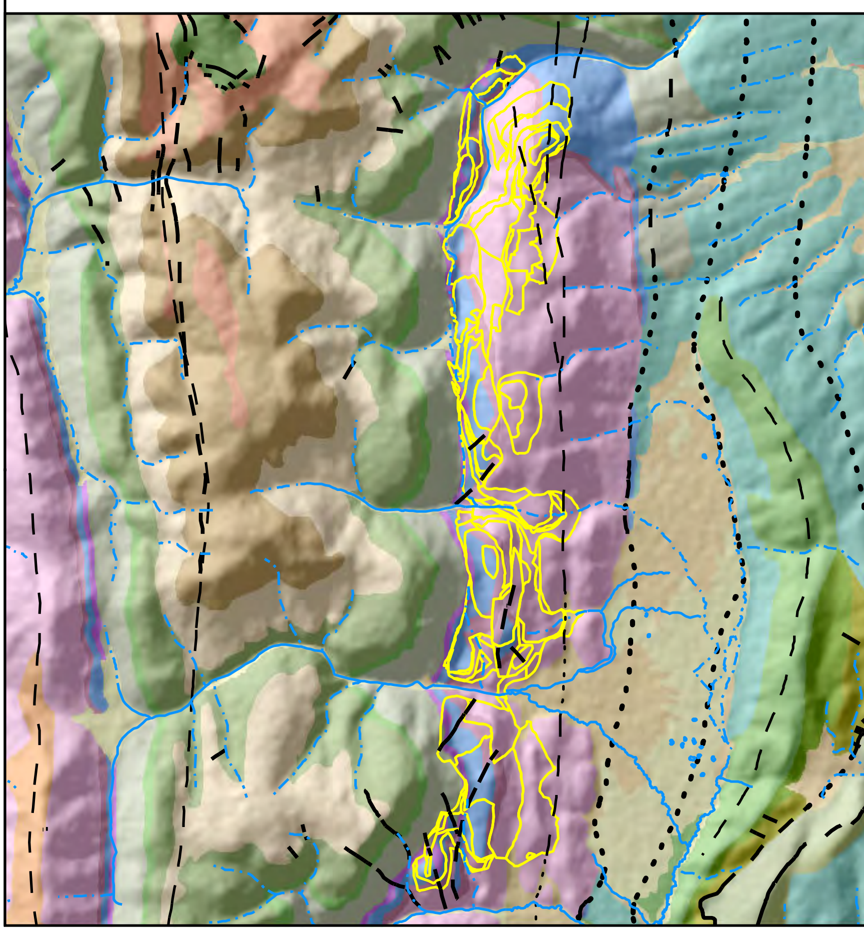
EXPLANATION FOR GEOLOGIC MAP

Geologic Map Units and Symbols

Age	Formation	Map Symbol	Description
Quaternary		Qt	Travertine
		Qc	Colluvium
		Qal	Alluvium
Tertiary	Salt Lake	Tsl	Salt Lake Formation
	Unconformity		
Jurassic	Nugget Sandstone	Jn	Nugget Sandstone
Triassic	Thaynes	Trtpu	Upper Portneuf Limestone Member
		Tral	Ankareh Formation - Lane Tongue
		Trtpl	Lower Portenuf Limestone Member
		Trtc	Thaynes C Member
		Trtb	Thaynes B Member
		Trta	Thaynes A Member
	Dinwoody	Trdu	Upper Dinwoody Formation
	Woodside	Trw	Woodside Formation
	Dinwoody	Trdl	Lower Dinwoody Formation
Permian	Phosphoria	Ppc	Cherty Shale Member
		Ppr	Rex Chert Member
		Ppm	Meade Peak Member
Pennsylvanian/Permian	Park City & Wells	Ppwu	Grandeur Member of Park City Formation and Upper Wells Formation
	Wells	Ppwl	Lower Wells Formation



Geologic Map Symbols

Contact (Dashed where inferred, dotted where buried)

Normal Fault (Dashed where inferred, dotted where buried)

Thrust Fault (Dashed where inferred, dotted where buried)

Syncline Axis

Anticline Axis

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SMOKY CANYON MINE RI/FS
FEASIBILITY STUDY TECH MEMO #1

FIGURE 2-2

EXPLANATION FOR GEOLOGIC MAP

DATE: JULY 2018		FORMATION ENVIRONMENTAL
BY: CRL	FOR: ACK	

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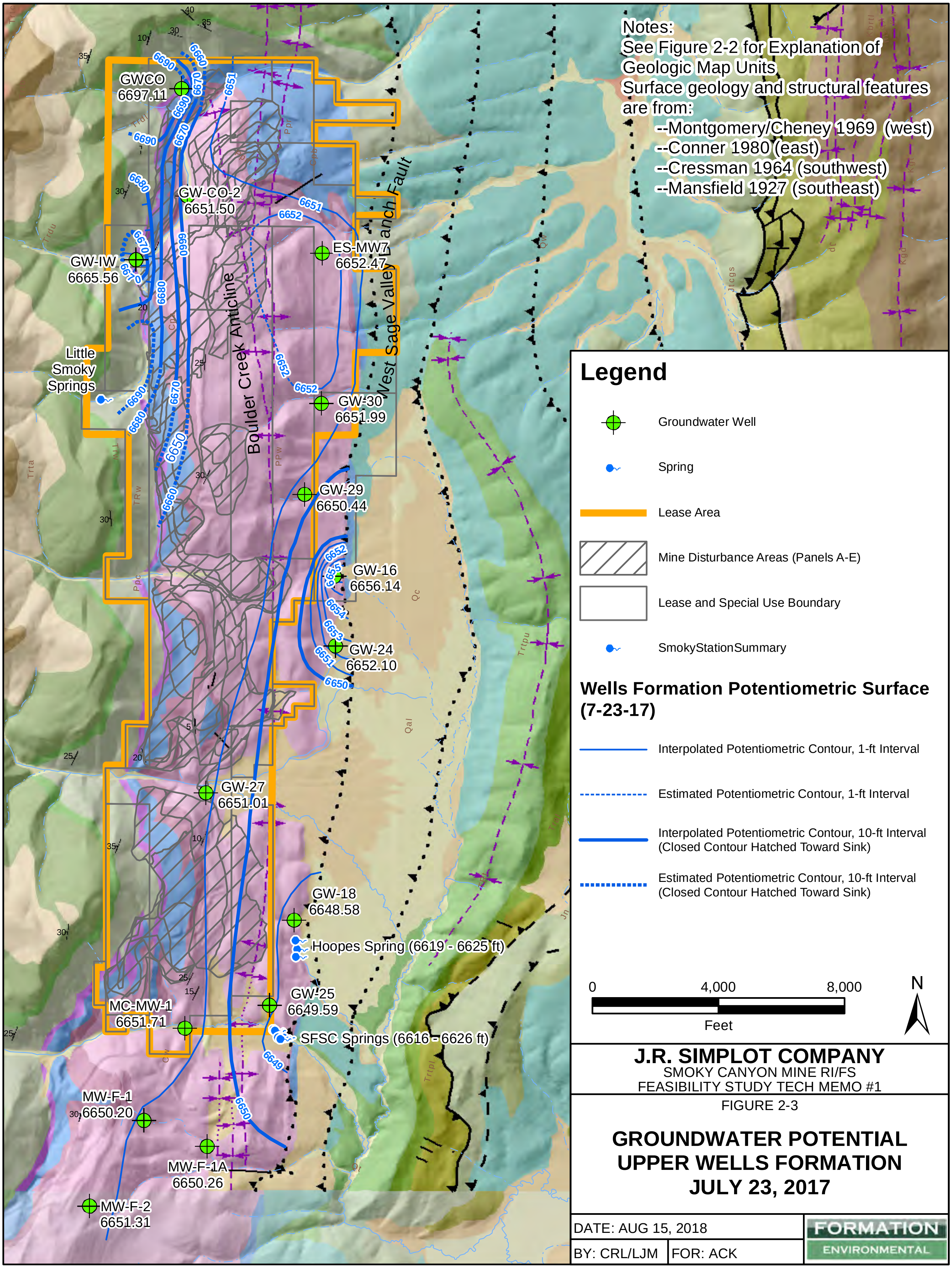

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FIGURE 2-3

GROUNDWATER POTENTIAL UPPER WELLS FORMATION JULY 23, 2017

DATE: AUG 15, 2018
BY: CRL/LJM FOR: ACK
FORMATION ENVIRONMENTAL

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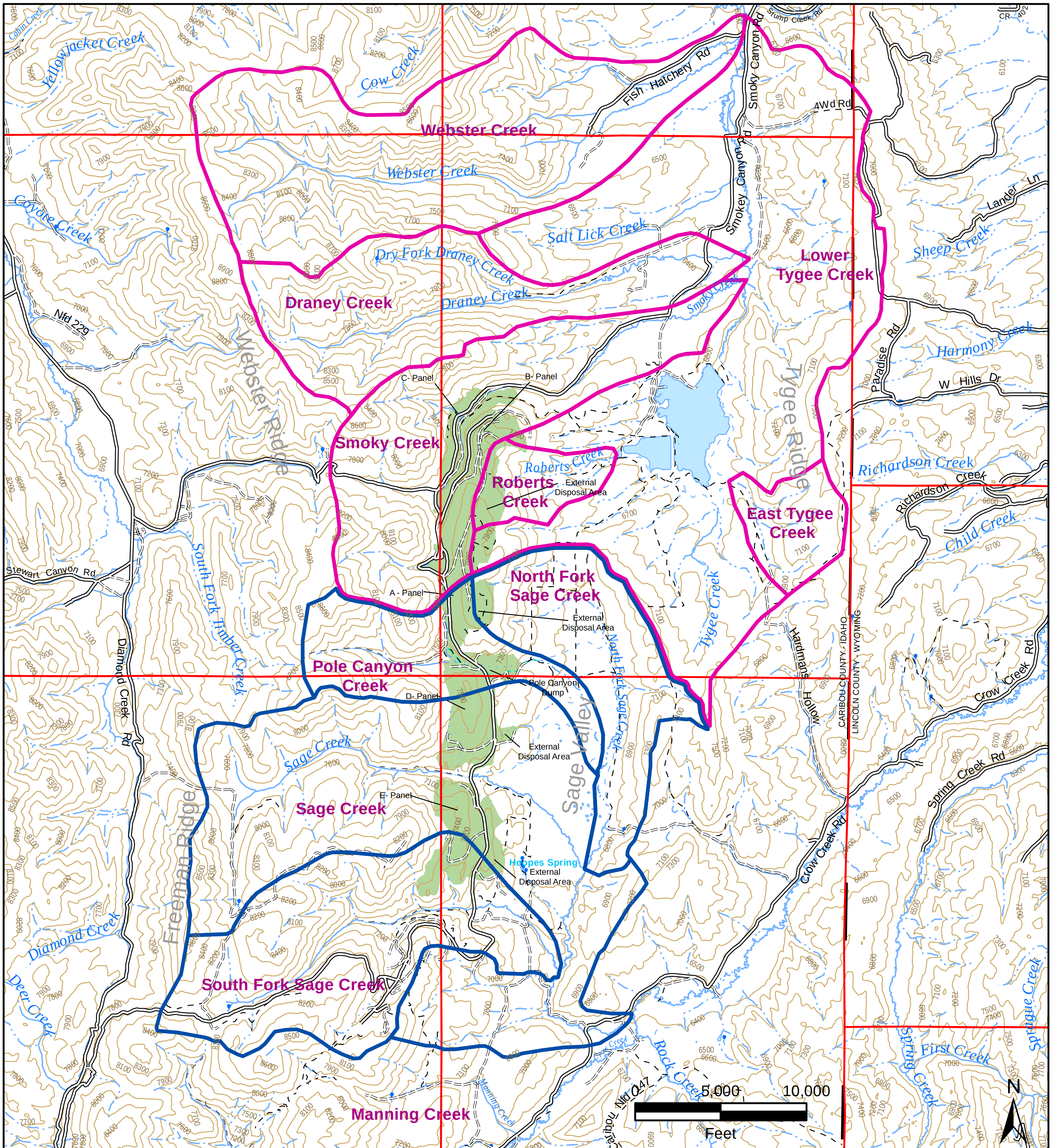

Legend

Minor Road	Intemittent Stream		
Unimproved Road	Perennial Stream		
Trail (4WD)	Lake/Pond		
Trail (Other than 4WD)	Mine Disturbance		
Pipeline	**Watershed Features**		
Historic Flow Path	Sage Creek Basin (Drains to Crow Creek)		
Canal Ditch	Tygee Creek Basin (Drains to Stump Creek)		

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SMOKY CANYON MINE RI/FS
FEASIBILITY STUDY TECH MEMO #1

FIGURE 2-4

SMOKY CANYON MINE AND VICINITY HYDROLOGIC FEATURES

DATE: JULY 2018

BY: CRL | FOR: ACK

FORMATION ENVIRONMENTAL

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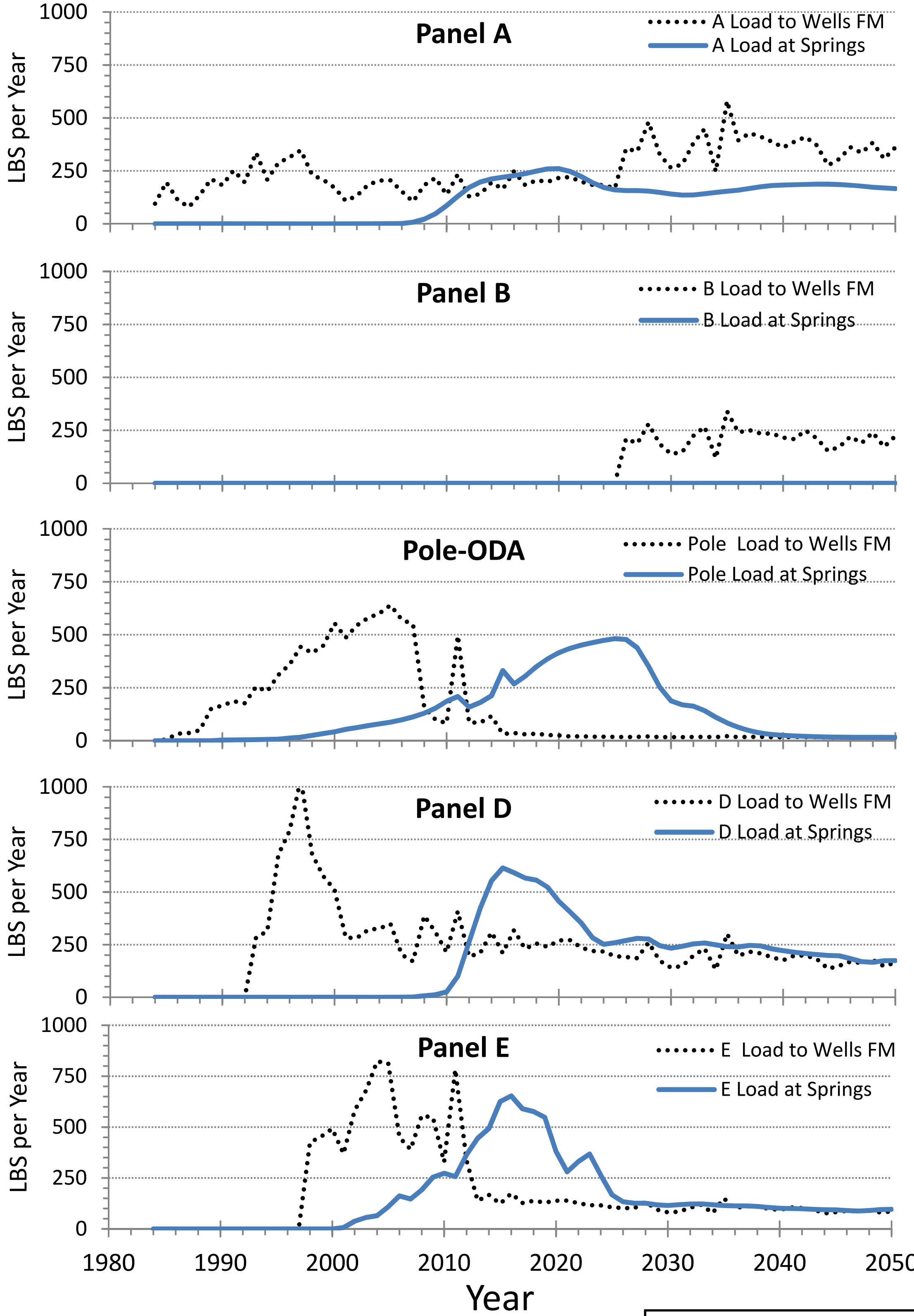

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SMOKY CANYON MINE RI/FS

FEASIBILITY STUDY TECH MEMO #1

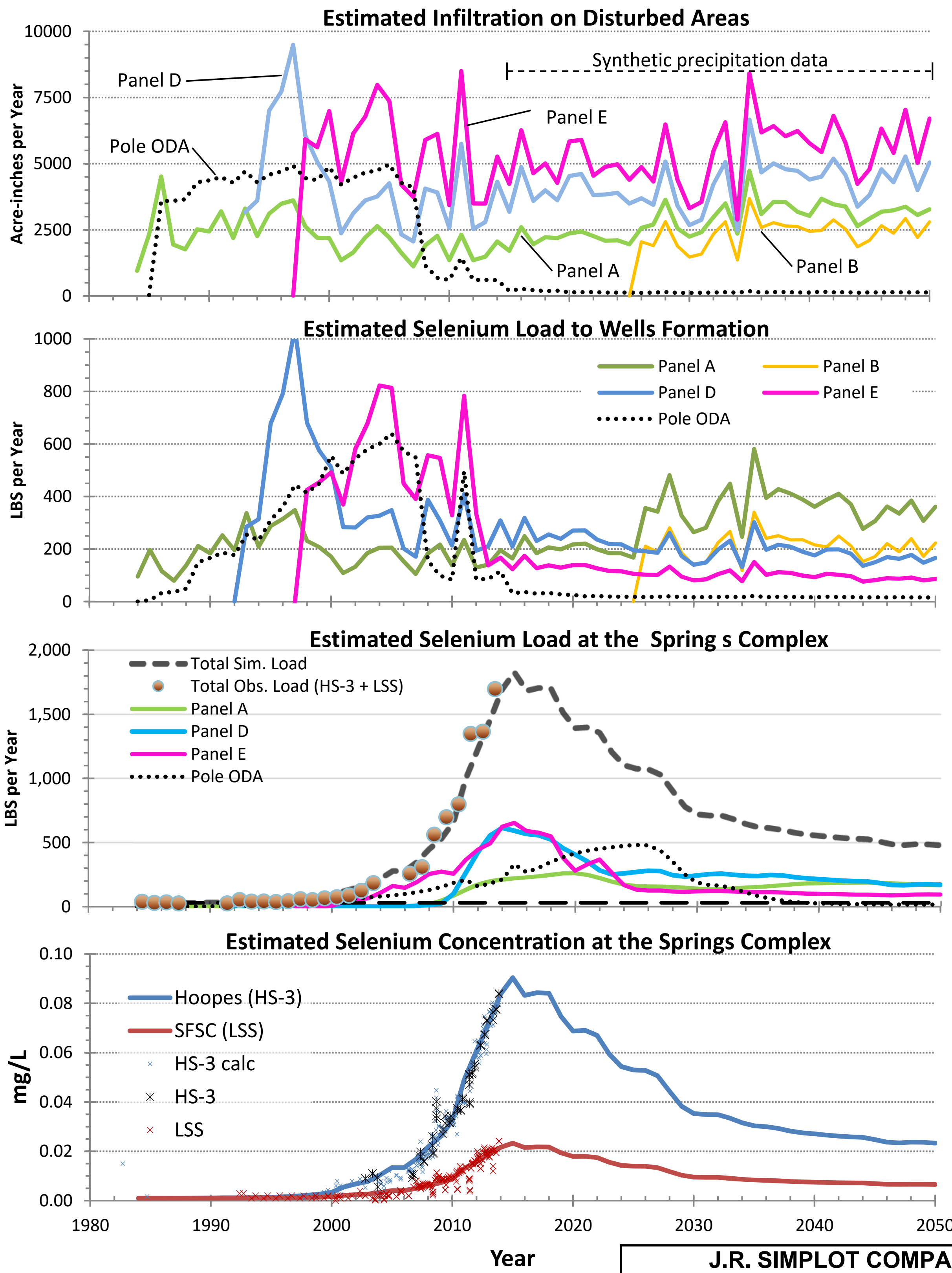
FIGURE 2-5

ESTIMATED SELENIUM MASS LOAD TO THE WELLS FORMATION AND ARRIVAL AT SPRINGS COMPLEX FOR EACH SOURCE AREA

DATE: JULY 2018

BY: PHT FOR: ACK

FORMATION ENVIRONMENTAL



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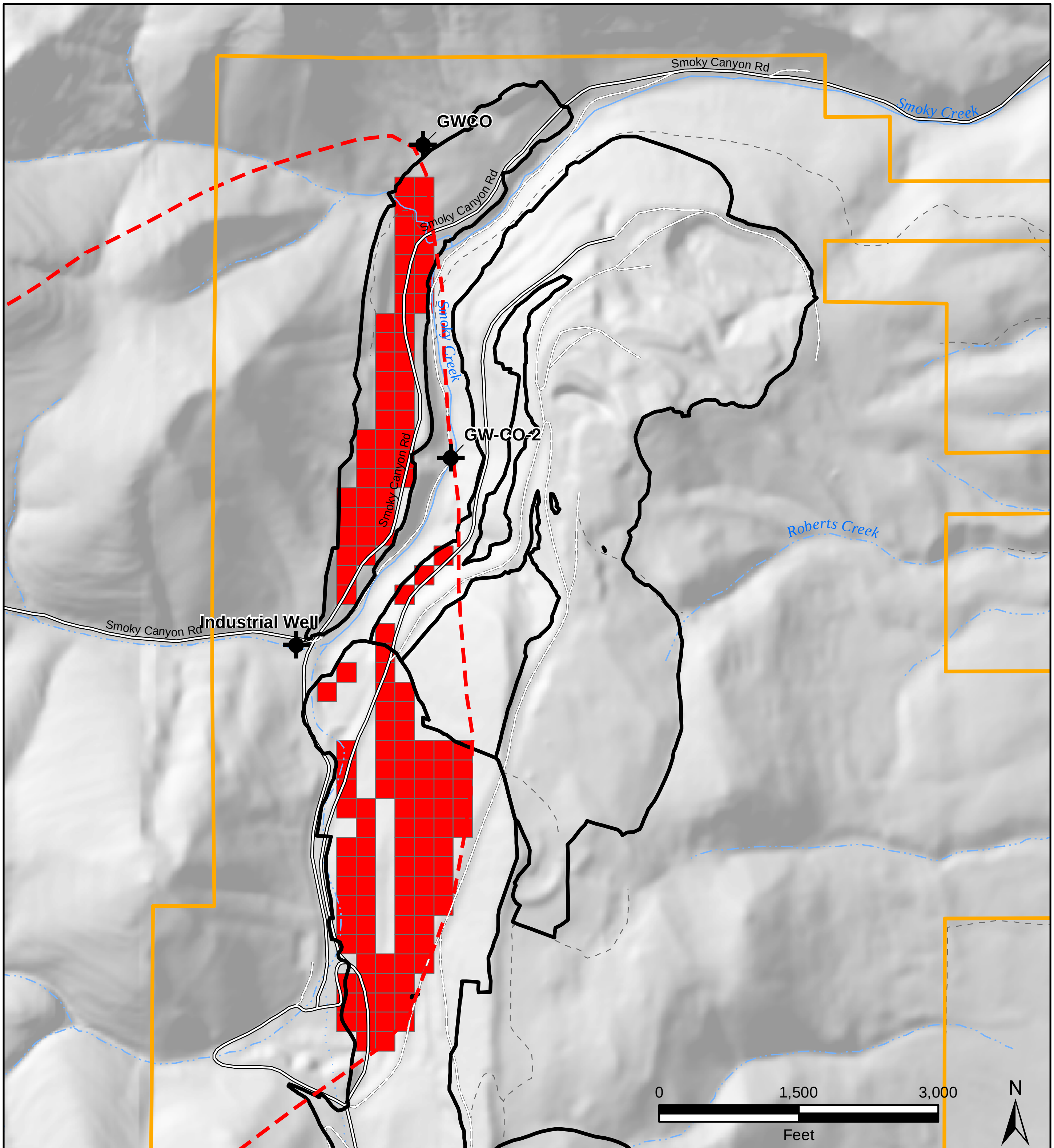
SMOKY CANYON MINE RI/FS
FEASIBILITY STUDY TECH MEMO #1

FIGURE 2-6

ESTIMATED INFILTRATION ON DISTURBERD AREAS, ESTIMATED SELENIUM LOADING TO WELLS FORMATION AND SPRINGS COMPLEX

DATE: JULY 2018		FORMATION ENVIRONMENTAL
BY: PHT	FOR: ACK	



Legend

Groundwater Monitoring Locations
Minor Road
Unimproved Road
Trail (4WD)
Historic Flow Path
Intemittent Stream
Perennial Stream
Lease Area
Structural Influence
Approximate Mine Panel Boundaries
Backfilled Areas (Source Cells) v2

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FIGURE 2-7

MODEL GRID CELLS REPRESENTING AREAS OF SELENIFEROUS BACKFILL (2012 CONDITIONS) INSIDE ASSUMED GW-IW CAPTURE ZONE

DATE: JULY 2018
BY: CRL
FOR: ACK

FORMATION ENVIRONMENTAL

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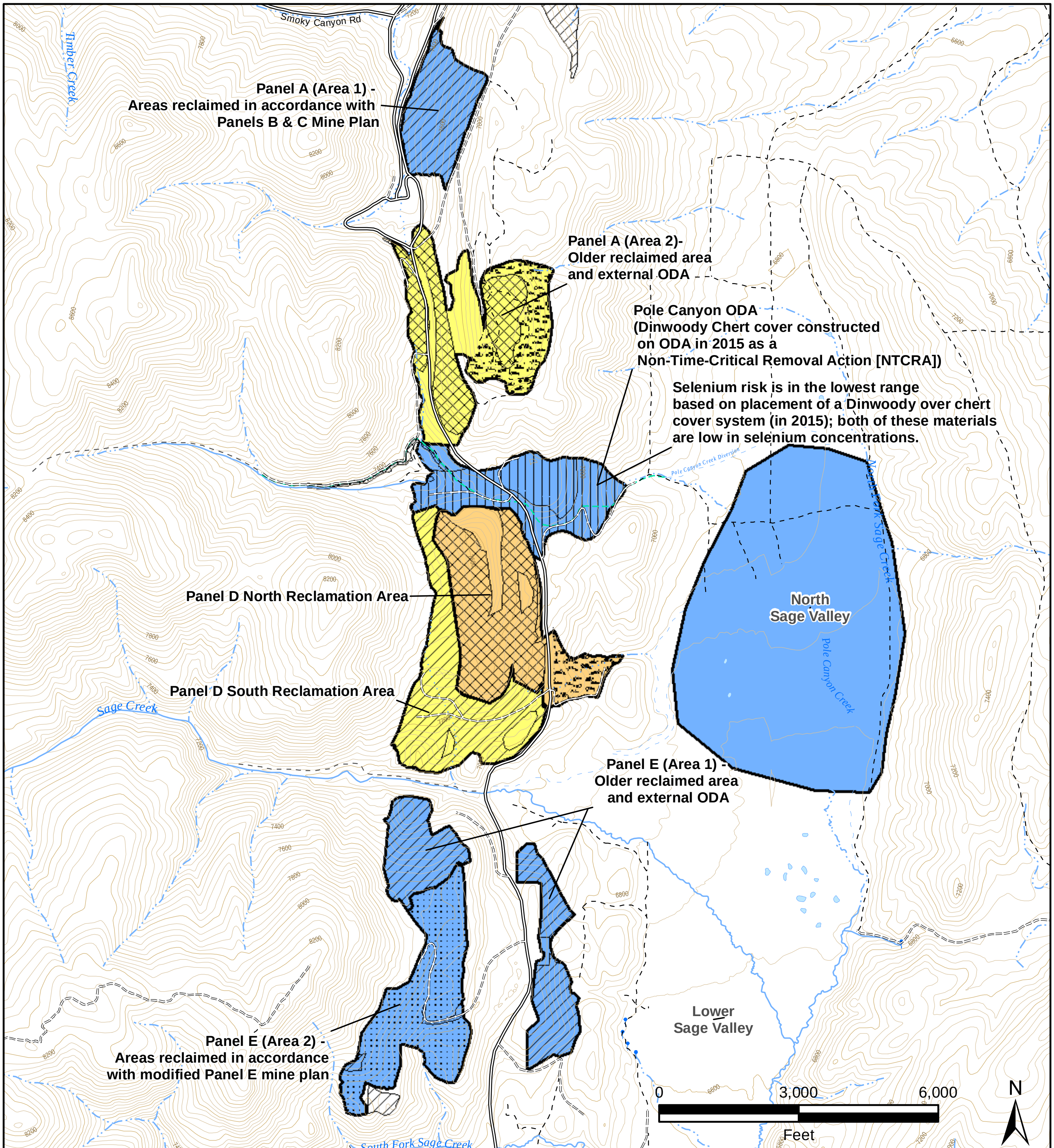

Legend

Cover Type

- DINWOODY CHERT (2015)
- TOPSOIL DINWOODY CHERT
- NO TOPSOIL NO CHERT
- TOPSOIL OVER CHERT
- TOPSOIL NO CHERT

Selenium Risk

- Lowest Risk
- Moderate - High Risk
- Highest Risk

- Minor Road
- Unimproved Road
- Trail (4WD)
- Trail (Other than 4WD)
- Index Contour (200 ft)
- Intermediate Contour (40 ft)

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FIGURE 2-8

SUMMARY OF SELENIUM RISK TO TERRESTRIAL BIOTA

DATE: SEP 21, 2018
BY: CRL
FOR: ACK

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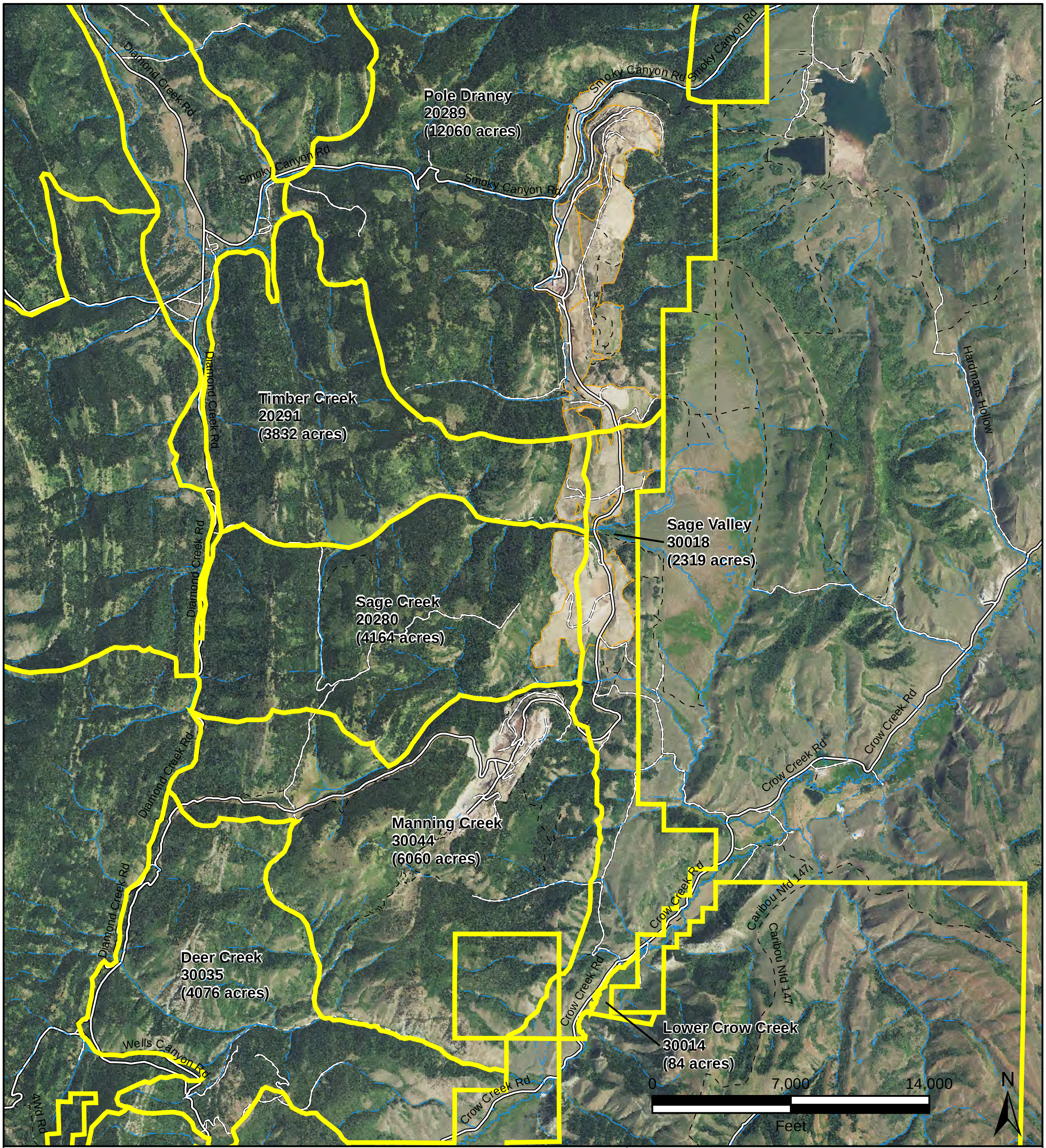

Legend

Grazing Allotment (USFS)

Mine Disturbance Area (Panels A-E)

Perennial Stream

Intermittent Stream

Allotments in vicinity of Smoky Canyon Mine are labeled.
Source: U.S. Forest Service (USFS). 2008. Range allotments shapefile - in Geographic Information System (GIS) coverages provided by Caribou National Forest, via e-mail. April 2008.
Aerial Source: 2013 NAIP photo from USDA

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FIGURE 2-9

USFS GRAZING ALLOTMENTS - WITH SATELLITE IMAGERY

DATE: SEP 21, 2018

BY: CRL | FOR: ACK

FORMATION ENVIRONMENTAL

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3.0 REMEDIAL ACTION OBJECTIVES

This section provides Site-specific objectives and goals for remedial actions at the mine. Preliminary RAOs were identified in the RI/FS Work Plan (Formation 2011a), based on the findings from the SI (NewFields 2005). These Preliminary RAOs have been updated in this section to incorporate the findings of the RI and risk assessments and the evaluation of ARARs.

Section 300.430(e) of the 1990 National Oil and Hazardous Substances Pollution Contingency Plan (NCP) requires that the remedial alternative development process be initiated by developing RAOs, identifying GRAs that address the RAOs, and performing an initial screening of applicable remedial technologies. The overarching goal of the remedy evaluation process is to provide the basis for selection of a remedy that is protective of human health and the environment and meets ARARs.

3.1 Environmental Conditions of Concern

Based on the key findings of the RI and risk assessments (see Section 2), the following environmental conditions of concern have been identified to be addressed by the Site remedy:

- Releases of selenium from overburden (both during mining and after mining) stored in backfilled pits and external ODAs with minimal or no covers that have resulted in MCL exceedances in groundwater in the Wells Formation aquifer including discharges at Hoopes Spring and South Fork Sage Creek springs and occasionally at the pumping Industrial Well (GW-IW) (Figure 3-1). The transport modeling for the RI Report (Appendix H, Formation 2014c), summarized in Figures 2-4 and 2-5, show relatively large releases of selenium to groundwater during active mining. The rate of release after mining depends on location specific conditions; primarily the aerial extent and the cover placed on the overburden. The relative magnitude of selenium loading from the sources to the springs in 2050 (i.e., after reclamation and NTCRA actions are fully effective) shows that Panel A Area 2 and Panel D (including the external ODA) are the primary sources (see the central panel on Figure 2-6, which shows selenium loading from these areas being higher than those predicted from Panel E and the Pole Canyon ODA). These areas are the focus of the FS evaluation for additional source control. Arsenic is also present at concentrations above the MCL in groundwater at some alluvial and Wells Formation wells (GW-15, GW-16) due to releases from the ODAs. These wells also have elevated selenium concentrations.
- Releases of selenium from overburden in the Pole Canyon ODA that have resulted in MCL exceedances in groundwater in the alluvial groundwater system in lower Pole Canyon and northern Sage Valley (GW-26, GW-15, GW-22) (Figure 3-1). These releases have been reduced as a result of the Pole Canyon ODA NTCRA cover constructed in 2015.
- Migration and discharge of Wells Formation groundwater to surface water at Hoopes Spring and South Fork Sage Creek springs resulting in selenium concentrations above the State of Idaho Surface Water Quality Criterion for Aquatic Life at the springs (HS-3, LSS) and downstream in lower Sage Creek (LSV-2, LSV-3, LSV-4) and Crow Creek (CC-

1A, CC-WY-01) (Figure 3-2). Other COCs that exceeded TRVs primarily in surface waters included aluminum, arsenic, cadmium, iron, nickel, and zinc.

- Risk to aquatic biota due to exceedances of whole body USEPA-derived and Simplot-derived fish tissue thresholds for selenium at Hoopes Spring (HS-3) and downstream from Hoopes Spring in lower Sage Creek (LSV-2, LSV-3, LSV-4) (Figure 3-3). Other COCs that were elevated in fish tissues included aluminum and essential micronutrients copper, iron, and zinc. However, risk related to these COCs may be overstated due to the contributions of background to tissue concentrations, as well as the reliability of the TRVs used to assess potential risks (Formation 2015b).
- Risk to terrestrial biota from soil/overburden and biotic media (vegetation, invertebrates, and small mammals) with elevated selenium concentrations in overburden on backfilled pits and external ODAs with minimal or no covers in the Panel A Area 2 (south of mill) and Panel D areas, and in overburden seep/riparian areas downgradient (east) of Panel D (DS-7), Panel E (ES-4), and the Pole Canyon ODA (LP-PD) (Figure 3-4). For terrestrial biota, risk from Pole Canyon ODA has been eliminated as a result of the Pole Canyon ODA NTCRA cover constructed in 2015. Other COCs were identified for terrestrial receptors including cadmium, chromium, copper, lead, manganese, molybdenum, vanadium, and zinc. However, exposure and risk associated with the non-selenium COCs are lower than predicted from selenium and were generally co-located with areas of selenium risk, primarily in mined areas with either no cover (i.e., direct revegetation of overburden) or relatively thin topsoil-only reclamation.
- Future risk to human receptors (recreational camper or Native American) and current risk to human receptors (Native American) from ingestion of surface water where arsenic concentrations exceeded the Idaho drinking water standard in surface water seeps downgradient (east) of Panel D (DS-7) and the Pole Canyon ODA (LP-1), and surface water in detention basins downgradient of Panel D seep DS-7 (DP-7) and Panel E (EP-2) (Figure 3-5).
- Future risk to human receptors (hypothetical resident) in which groundwater from wells on private lands is used for domestic drinking water supply, where arsenic concentrations in groundwater exceeded the MCL immediately downgradient of the Pole Canyon ODA (GW-15, GW-16) (Figure 3-5).
- Future and current risk to human receptors (seasonal rancher) from ingestion of beef as the primary contributor of cancer risk, based largely on arsenic concentrations (calculated on a Site-wide basis) for soil with the highest concentrations in Panel A Area 2, detention basin AP-3 (adjacent to west end of Pole Canyon ODA), Panel D seep DS-7 area, detention basin DP-7, and detention basin EP-4 (Figure 3-5). As noted in Section 2.5, thallium exposures to human receptors (Seasonal Rancher) from beef consumption were elevated (with considerable uncertainty in the uptake coefficient), although data from regional studies suggest that thallium concentrations in soils at the Site are within the range of natural background concentrations.
- Future risk to human receptors (hypothetical resident) in which groundwater from wells on private lands is used for domestic drinking water supply, where selenium concentrations in groundwater exceeded the MCL immediately downgradient of the Pole Canyon ODA (GW-15, GW-16) and downgradient of Pole Canyon in northern Sage Valley (GW-22, MP01, MP02, and MP03) (Figure 3-6).

USEPA has stated that domestic species, like cattle, are a commodity as well as alfalfa hay (USEPA 2018). By extension, grazing plants can also be considered a commodity. USEPA's Office of General Counsel (OGC) has opined that CERCLA actions should not establish cleanup numbers for a commodity. Therefore, livestock are not considered further in this FS.

3.2 Applicable or Relevant and Appropriate Requirements

Identification and evaluation of ARARs are integral components of the FS process to determine whether remedial alternatives can protect human health and the environment. The development of remedial alternatives under CERCLA relies, in part, on the identification of the ARARs which any action must meet, unless specific ARARs qualify for a waiver and are waived.

<u>Applicable, Relevant and Appropriate, and To-Be-Considered Standards</u>

For onsite activities, CERCLA requires compliance with both applicable requirements (i.e., those that would apply to a given circumstance at any site or facility) and those that the Forest Service deems to be relevant and appropriate (even though they do not apply directly), based on the unique conditions at a site. Applicable requirements are cleanup standards; standards of control; and other substantive requirements, criteria, or limitations promulgated under federal or state laws that specifically address a hazardous substance, constituent, removal action, location, or other circumstance found at a site. Relevant and appropriate requirements, while not applicable to a hazardous substance, pollutant, contaminant, removal action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the site such that their use is well-suited (40 Code of Federal Regulations [CFR] 300.5).

ARARs are potential or preliminary until finalized in the ROD. The NCP provides for the waiver of ARARs under certain circumstances as per 40 CFR 300.415(f)(1)(i)(C). Because this is a preliminary evaluation of potential ARARs, with remedial alternatives still being developed, any identification of the need for ARAR waivers is preliminary.

In addition to ARARs, the NCP states that where ARARs do not exist, agency advisories, criteria, or guidance are to be considered useful "in helping to determine what is protective at a site or how to carry out certain actions or requirements" (55 Federal Register 8745). These sources of information are referred to as "To-Be-Considered" (TBC) standards.

The NCP preamble states, however, that provisions in the TBC category "should not be required as cleanup standards, because they are, by definition, generally neither promulgated nor enforceable, so they do not have the same status under CERCLA as do ARARs." Although not enforceable requirements, these documents are important sources of information that the regulatory agencies may consider during selection of the remedy, especially regarding the evaluation of public health and environmental risks, or which will be referred to, as appropriate, in selecting and developing cleanup actions (40 CFR § 300.400(g)(3), 40 CFR § 300.415(I)).

State Regulations

State requirements are potential ARARs for CERCLA response actions as long as they meet the following eligibility criteria:

- State law or regulation
- Environmental or facility siting law or regulation
- Promulgated (of general applicability and legally enforceable)
- Substantive (not procedural or administrative)
- More stringent than federal requirements
- Identified in a timely manner
- Consistently applied

Many state requirements listed as ARARs are promulgated with identical or nearly identical requirements to federal law pursuant to delegated environmental programs administered by federal agencies and the state.

Types of ARARs

There are three primary types of ARARs: chemical-specific, location-specific, and action-specific. An ARAR can be one or a combination of all three types.

Chemical-specific requirements address chemical or physical characteristics of compounds or substances at sites. These values establish acceptable amounts or concentrations of contaminants that may be found in, or discharged to, the ambient environment.

Location-specific requirements are restrictions placed on the concentrations of hazardous substances or the conduct of cleanup activities, because they are in specific locations. Location-specific ARARs relate to the geographical or physical positions of sites rather than the nature of contaminants at sites.

Action-specific requirements are usually technology-based or activity-based requirements, or limitations on actions taken with respect to hazardous substances, pollutants, or contaminants. A given cleanup activity will trigger an action-specific requirement. Such requirements do not themselves determine the cleanup alternative but define how chosen cleanup methods should be performed.

ARAR Waivers

CERCLA Section 121(d)(4) authorizes that any ARAR may be waived per one of the following six conditions if the protection of human health and the environment is ensured:

- It is part of a total remedial action that will attain such level or standard of control when completed (i.e., interim action waiver).
- Compliance with the ARAR at a given site will result in greater risk to human health and the environment than alternative options that do not comply with the ARAR.
- Compliance with such a requirement is technically impracticable from an engineering perspective.
- The remedial action will attain a standard or performance equivalent to that required by the ARAR through use of another method or approach.
- The ARAR in question is a state standard and the state has not consistently applied (or demonstrated the intention to consistently apply) the ARAR in similar circumstances at other sites.
- In meeting the ARAR, the selected remedial action will not ensure a balance between the need for protection of public health and welfare and the environment at the site and the availability of Superfund monies to respond to other facilities.

NEPA Permits

Mining operations at Smoky Canyon are permitted under the National Environmental Policy Act (NEPA) (42 U.S.C §4321 et seq.) to ensure that environmental standards are maintained from the beginning to the end of mining operations. The NEPA process requires an EIS to evaluate the potential environmental and human consequences of the federal actions required to authorize mining operations and the site-specific mitigation measures and environmental monitoring required for protection of the environment. Currently, active permitted mining areas are Smoky Canyon Mine Panels A through G. A new East Smoky Panel located east of Panel B is in the Draft EIS phase of the NEPA process and has not been permitted.

CERCLA Permit Exemption

CERCLA Section 121(e)(1), 42 United States Code (U.S.C). § 9621(e)(1), states, “No Federal, State, or local permit shall be required for the portion of any removal or remedial action conducted entirely onsite, where such remedial action is selected and carried out in compliance with this section.” The onsite activities must, however, comply with substantive permit requirements. The term “onsite” is defined in the NCP as “the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action” (40 CFR § 300.5).

Simplot conducted a preliminary identification of potential ARARs (chemical-specific, location-specific, and action-specific) as presented in the RI/FS Work Plan (Formation 2011a). This analysis has been refined relative to findings of the RI and risk assessments and the scope of potential actions to be performed. A summary of potential ARARs and TBCs are presented in Tables 3-1 and 3-2.

As discussed in Section 3.4, a process to modify the aquatic water quality standard is underway and it is possible that a new standard will be adopted by the time the ROD is signed or shortly thereafter.

3.3 Remedial Action Objectives

This section presents the RAOs to address the key environmental issues described in Section 3.1 and the evaluation of ARARs in Section 3.2. The RAOs specify COCs and environmental media of concern, exposure routes, and receptors, and are intended to provide protection of human health and the environment.

Groundwater

- Prevent future use of alluvial or Wells Formation groundwater with arsenic or selenium concentrations above MCLs as a drinking water source.
- Reduce or eliminate concentrations of arsenic and selenium in contaminated Wells Formation and alluvial groundwater to below MCLs within a reasonable time frame given the circumstances of the Site.[1]
- Reduce or eliminate loading of selenium from groundwater to surface water so that it does not result in concentrations that represent an unacceptable risk to aquatic life in the lower Sage Creek and Crow Creek watersheds.
- Reduce or eliminate loading of selenium from groundwater to surface water so that it does not result in concentrations above the Aquatic Water Quality Standard in the lower Sage Creek and Crow Creek watersheds.

Soils/Overburden

- Reduce or eliminate unacceptable risks to future Seasonal Ranchers from ingestion of beef from livestock grazing on ODAs as the primary contributor of cancer risk, due to arsenic concentrations (calculated on a Site-wide basis) for soil.
- Reduce or eliminate unacceptable risks to terrestrial biota from soil with elevated selenium concentrations on overburden or backfilled pits and external ODAs with

[1] The detailed analysis will provide an evaluation of the predicted future changes in selenium concentrations in groundwater at key locations (and changes in concentration and load at the springs complex) for the No Further Action alternative and the different action alternatives. This evaluation will provide the basis for establishing a "reasonable time frame".

minimal or no covers and in overburden seep/riparian areas downgradient of ODAs.

Surface Water

- o Reduce or eliminate unacceptable risks to human receptors from ingestion of non-regulated surface water (seeps and detention ponds) due to arsenic.
- o Reduce selenium concentrations in lower Sage Creek and Crow Creek watersheds to below levels that pose unacceptable risks for aquatic life.
- o Reduce selenium concentrations in lower Sage Creek and Crow Creek watersheds to below the Aquatic Water Quality Standard (IDAPA 58.01.02 – Water Quality Standards).

3.4 Preliminary Remediation Goals

PRGs specify quantifiable goals for COCs in environmental media to address the RAOs. Remedial action implemented for the purpose of meeting PRGs usually results in attainment of RAOs. A summary of the PRGs is provided in Table 3-3.

Regulated Surface Water: Idaho Water Quality Standard for Selenium

Elevated selenium concentrations in Hoopes Spring, lower Sage Creek, and lower Crow Creek pose unacceptable risks for aquatic life (Formation 2012d). The current state standard for aquatic life in Idaho is 5 µg/L, which is applicable for surface water at all locations within the watershed. Recently, the USEPA released its 2016 Final Aquatic Life Criterion for Selenium. It includes several elements for the criterion, including an egg/ovary element, a whole body or muscle element, and a water element. The selenium aquatic life criterion is based on effects relative to tissue concentrations in fish due to exposure through diet.

The State of Idaho has completed its rulemaking process to update the selenium criteria for aquatic life use. The proposed rule replaces the existing water column-based criteria for selenium with a four-part criterion. The recommended elements are: (1) a fish egg-ovary element; (2) a fish whole-body and/or muscle element; (3) a water column element which includes one value for lentic (still water) and one value for lotic (running water) aquatic systems; and (4) a water column intermittent element to account for potential chronic effects from short-term exposures (one value for lentic and one value for lotic aquatic systems).

The proposed rule also includes the addition of Section 287, Site-Specific Aquatic Life Criteria for Selenium. Subsections 287.01 through 287.04 were developed in response to proposals for site-specific selenium criteria submitted by Nu-West Industries, Inc. and J.R. Simplot Company. Subsections 287.03 and 287.04 set out the site-specific selenium criteria for Hoopes Spring, Sage Creek, and Crow Creek near the Smoky Canyon Mine. This rulemaking has been adopted by the

Idaho State Legislature and is now awaiting approval or disapproval by the USEPA. If the site-specific criteria adopted by the State of Idaho for Sage Creek and Crow Creek are approved by USEPA, they will supersede the current 5 µg/L standard for lower Sage Creek and lower Crow Creek to the Wyoming border. A USEPA response on the pending criterion is expected to occur in the future.

<u>Groundwater</u>

The primary goals for groundwater are based on the selenium (0.05 mg/L) and arsenic (0.01 mg/L) MCLs. These levels have been developed to protect the aquifer or drinking water source and to protect human health.

<u>Non-Regulated Surface Water</u>

The SSHHRA identified potentially unacceptable risks to humans from drinking water in seep areas or from detention ponds. The PRG for this pathway was set at the drinking water MCL for arsenic (0.01 mg/L), applicable at each seep or detention basin.

<u>Soils and Overburden</u>

Estimated potential risks to wildlife populations from exposure on Panels A and D were mainly from the potential for selenium to accumulate in vegetation or invertebrates and in small home range receptors. Although HQs greater than 1 were calculated for the large home range receptor, the SSERA concluded that risks of impact from chronic selenium exposure to wide-ranging species such as deer, elk, coyotes, and raptors is relatively lower than for the small home range receptors because these species feed over wide areas and would be exposed to soils, vegetation, terrestrial invertebrates, and small mammalian prey items on the panels for short periods.

Segments of populations of smaller-bodied wildlife such as rodents and songbirds may experience more chronic exposure to soils and vegetation on the mine panels. Risk of adverse effects from selenium exposure is greater for the individuals that spend most or all of their time on the mine panels. However, although uncertain, risk to overall Site populations is low because most of the Site and adjacent areas are not affected by mine disturbances and contain natural selenium concentrations.

The RAO for ingestion of beef at the Site focuses on prevention of unacceptable risks to future seasonal ranchers due to arsenic concentrations in surface soil (calculated on a Site-wide basis). Section 6.2.1 of the Smoky SSHHRA described the estimated risks to seasonal ranchers from ingestion of beef. The background arsenic concentration in soils was estimated at 11.5 mg/kg as the 95 percent upper simultaneous limit (95USL) for pooled values (all background samples combined) (MWH 2015), as also presented in the Smoky SSHHRA (Formation 2015a). The 95 percent upper confidence limit (95UCL) for arsenic concentrations in soil were 5.6 mg/kg on private lands and 16.2 mg/kg Site-wide. The highest upper-bound estimates of average concentrations were on the uncovered ODAs, on Panel A Area 2 (27.5 mg/kg) and D Panel (14.7 mg/kg). Based on the risk estimation approach and the Site data, a PRG of 11.5 mg/kg mean arsenic concentrations for the Site-wide concentration has been established. The upper estimate of the average (e.g., 95UCL of the mean) arsenic concentration will be compared to the PRG.

TABLE 3-1. Applicable or Relevant and Appropriate Requirements (ARARs)

Type of ARAR	Statute, Regulation, Standard, or Requirement	Citation or Reference	General Description	Site-Specific Comments	Determination
Federal					
Chemical-Specific	National Primary Drinking Water Regulations (NPDWR)	40 C.F.R. Part 141	Establishes primary drinking water regulations pursuant to Section 1412 of the Public Health Service Act, as amended by the Safe Drinking Water Act and related regulations for public water systems. Subpart F Section 141.51 lists maximum contaminant level goals (MCLGs) for inorganic contaminants. Subpart G Section 141.62 lists maximum contaminant levels (MCLs) for inorganic contaminants.	Hydrogeologic investigations for the RI at Smoky Canyon Mine show that the Thaynes-Dinwoody Formation and Wells Formation produce water. Groundwater from the Culinary Well is used as a private drinking water supply at the Smoky Canyon MIne. Primary drinking water regulations are applicable if groundwater beneath the Site will be used to supply public water systems.	Applicable
	Water Quality Standards	CWA Section 304 33 U.S.C. § 1314(a) 40 C.F.R. Part 131	Section 304 of the federal Clean Water Act (33 U.S.C § 1314) requires that individual states establish water quality standards for surface waters. The implementing regulation establishes the Ambient Water Quality Criteria (AWQC), which are the requirements for state water quality standards that are protective of human health and aquatic life. The standards incorporate designated uses for specific water bodies.	The State of Idaho has adopted the federal water quality criteria. Where numeric state water quality standards have not been promulgated, federal numeric water quality standards are applicable.	Applicable
	Resource Conservation and Recovery Act (RCRA)	40 C.F.R. §§ 261.20 to 261.24	Under RCRA, solid wastes that exhibit certain characteristics are subject to regulation as hazardous wastes. A solid waste is identified as hazardous if it exhibits the characteristic of ignitability, corrosivity, reactivity, or toxicity. Using the toxicity characteristic leaching procedure (Test Method 1311), if extract from the solid waste contains any of the contaminants at concentrations greater than or equal to those listed in Section 260.24, then the solid waste exhibits the characteristic of toxicity and is identified as a hazardous waste.	Potentially applicable if solid wastes are generated as part of the selected remedy. If the selected remedy includes a water treatment system, water treatment residual material or sludge will be tested to determine if the material exhibits the characteristic of toxicity and is hazardous under RCRA to determine proper disposal.	Applicable
	National Pollutant Discharge Elimination System (NPDES)	CWA Section 402 33 U.S.C 1342 40 C.F.R. §§ 122 to 125	Permitting requirements for the discharge of pollutants from any point source. USEPA considers discharges from waste dumps or overburden disposal areas (ODAs) (e.g., springs and seeps at the base of the dumps) as point sources. The NPDES regulations establish requirements for point source discharges and stormwater runoff.	NPDES regulations are potentially applicable for any point source discharge of contaminated water or stormwater runoff at the Smoky Canyon Mine, and management of stormwater runoff during construction where the construction site is 1 acre or more in size. Best Management Practices (BMPs) will be used to manage stormwater runoff during construction of the remedy.	Applicable
Action-Specific	Clean Water Act (CWA)	CWA Section 301(b) CWA Section 402 40 C.F.R. § 125.3	Sections 301(b) and 402 of the Clean Water Act establish criteria and standards for technology-based treatment requirements, including the application of EPA promulgated effluent limitations. The effluent limitations require the best treatment and control technology prior to discharge.	The Hoopes Water Treatment Plant (WTP) pilot study at the Smoky Canyon Mine currently discharges to Hoopes Spring. Technology-based treatment requirements are applicable if the final remedy involves water treatment and discharge. Best treatment and control technology will be developed as part of the FS process and implemented during remedial design.	Applicable
		CWA Section 303(d) 33 U.S.C. §1251 et seq. 40 C.F.R. § 130.7	Under Section 303(d) of the Clean Water Act, states, territories and authorized tribes are required to submit lists of impaired waters. These are waters not meeting applicable water quality standards for one or more beneficial uses by one or more pollutants. The law requires that the states develop EPA approved Total Maximum Daily Loads (TMDL) for those Category 5 waters found on the 303(d) list.	The Salt River subbasin waterbodies on the 303(d) list have a medium priority for TMDL development. Streams near the Smoky Canyon Mine listed on the 2014 303(d) list include the following: Smoky Creek, Roberts Creek, Crow Creek, Tygee Creek, North Fork Sage Creek, Sage Creek, Pole Canyon, and South Fork Sage Creek. Those stream segments listed specifically for selenium include: Crow Creek (Deer Creek to border), North Fork Sage Creek, Pole Canyon Creek, South Fork Sage Creek, Sage Creek (confluence with North Fork Sage Creek to mouth). Those 303(d) waterbodies listed for selenium will be assessed for applicability of ARARs and considered in the selection of the remedial alternative.	Applicable
		CWA Section 401 13 U.S.C. § 1341 40 C.F.R. § 124.53	Under Section 401 of the Clean Water Act, a federal agency cannot issue a permit (e.g., Section 402 NPDES permit, or Section 404 permit for discharge of dredged or fill material) or license for an activity that may result in a discharge to waters of the U.S. until the state where the discharge would originate has granted or waived the Section 401 certification. The Section 401 certification can be an effective tool for protecting water quality.	Potentially applicable for remedial actions that result in a point source discharge (i.e., discharge from a water treatment system) or discharge of dredged and fill material (e.g., road building, construction of a cover system, or other activities that cross or impact stream channels) that requires a permit. Simplot would be required to submit a Section 401 certification with the federal permit application.	Applicable
		CWA Section 402 13 U.S.C. § 1342 40 C.F.R. Parts 122 to 124	The NPDES program under Section 402 of the Clean Water Act establishes a comprehensive framework for addressing waste water and storm water discharges, and requires that point-source discharges not cause the exceedence of surface water quality standards outside the mixing zone. The NPDES program requires permits for the discharge of pollutants from any point source into waters of the U.S. Section 122.26 specifies requirements for point source discharge of storm water from construction sites to surface water and provides for Best Management Practices (BMPs) such as erosion control for removal and management of sediment to prevent run-on and runoff.	A water treatment system and/or storm water conveyance systems such as run-on/runoff control ditches or detention basins may be constructed as part of the final remedy. Potentially applicable if the remedy creates a point source discharge (i.e., from a water treatment system) or for storm water management during construction or for any storm water conveyance systems constructed at the Smoky Canyon Mine. A Section 402 NPDES permit would be required for any such discharge.	Applicable
		CWA Section 404 33 U.S.C. §1344 40 C.F.R. Part 230	Section 404 of the Clean Water Act establishes a program to regulate the discharge of dredged and fill material into waters of the U.S. including wetlands. Section 404 requires a permit before dredged or fill material may be discharged. No discharge of dredged or fill material may be permitted if a practicable alternative exists that is less damaging to the aquatic environment, or the waters would be significantly degraded.	A Section 404 permit for discharges of dredged or fill material to wetlands is required for remedial actions that may result in a discharge to surface water (e.g., road building, construction of a cover system, or other activities that cross or impact stream channels). The design of the final remedy will be developed to minimize or avoid impacts. Compensatory mitigation for unavoidable loss of aquatic habitat and/or wetlands will be developed during remedial design and constructed during implementation of the remedy.	Applicable
	Resource Conservation and Recovery Act (RCRA)	42 U.S.C. § 6901 et seq. 40 C.F.R. Parts 260 to 265 and 268	Subtitle C of RCRA addresses requirements for hazardous waste from the point of generation to disposal. Any solid waste that exhibits a characteristic of hazardous waste or falls under a category of listed hazardous waste must be managed under these requirements. The requirements apply to transportation, treatment, storage, or disposal of the hazardous waste.	Potentially applicable if solid wastes are generated as part of the selected remedy. For example, if the selected remedy includes a water treatment system, water treatment residual material or sludge will be tested to determine if the material is hazardous prior to transport or disposal.	Applicable

TABLE 3-1. Applicable or Relevant and Appropriate Requirements (ARARs)

Type of ARAR	Statute, Regulation, Standard, or Requirement	Citation or Reference	General Description	Site-Specific Comments	Determination
Federal					
Action-Specific	Mineral Leasing Act (MLA)	30 USC § 181 et seq. 43 CFR Parts 3500 and 3590	Regulates discovery, mining, processing and reclamation on federal phosphate leases. Section 3592.1 establishes requirements for operating plans that detail exploration and mining operations. The plans must be responsive to the lease requirements for the protection of nonmineral resources and for reclamation of the surface of the lands affected by the operations.	Provisions regarding reclamation are potentially applicable. For affected areas that require revegetation (e.g., covers on overburden disposal areas), the plan will include the proposed methods of preparation and fertilizing of the soil prior to replanting, the types and mixtures of grasses to be planted, and the methods of planting including the amount of grasses per acre.	Applicable
	Surface Mining Control and Reclamation Act (SMCRA)	30 U.S.C §§ 1201–1326 30 C.F.R. Part 816.43, 45–47, 111 30 C.F.R Part 784	The SMCRA establishes permanent program performance standards for surface mining operations. The SMCRA also establishes minimum requirements for coal mining operations and reclamation of mined areas to protect society and the environment.	These requirements are not applicable because the Smoky Canyon Mine is not a coal mine. The requirements may be relevant and appropriate to the design of a cover and runoff and run-on control system as part of the final remedy.	Relevant and Appropriate
	Clean Air Act (CAA)	40 C.F.R. Part 50 40 C.F.R § 52.670	Establishes National primary and secondary ambient air quality standards under Section 109 of the CAA to protect the public health and welfare.	Federal standards for particulate matter (PM) may be relevant and appropriate if dust is generated during construction of the remedy.	Relevant and Appropriate
	National Emissions Standards for Hazardous Air Pollutants (NESHAP)	40 C.F.R Part 61	Establishes numerical emission limits under the CAA for hazardous air pollutants and other substances that cause serious health effects emitted from stationary sources. In addition to complying with the provisions of this part, the owner or operator of a stationary source may be required to obtain an air pollution control permit.	The State of Idaho's air quality standards govern air quality at the Smoky Canyon Mine; therefore, NESHAP requirements are not applicable but may be relevant and appropriate for stationary sources of air pollution.	Relevant and Appropriate
	National Environmental Policy Act (NEPA)	40 C.F.R. Parts 1500–1508 42 U.S.C § 4321 et seq.	NEPA requires federal agencies to assess the environmental effects of proposed actions prior to making decisions, and includes making decisions on permit applications, adopting land management actions, and constructing facilities. NEPA provides for consideration of the potential impacts of response actions on the environment and provides for significant public participation.	The NEPA process was completed for each of the active permitted mine panels at Smoky Canyon. An environmental impact statement (EIS) was prepared to consider the environmental effects of the proposed mining actions. The permit approvals included stipulations for protection or management of water resources, fish and wildlife, recreation and public access, transportation and utility corridors, livestock, air resources, housing and community facilities, slurry pipeline, timber, reclamation and revegetation, fire and safety, refuse and garbage, cultural and visual resources, and provide for environmental monitoring. The NEPA process is applicable to any future mining projects for assessment of individual and cumulative impacts.	Applicable
	Migratory Bird Treaty Act (MBTA)	16 U.S.C. § 703 et seq.	Prohibits pursuing, hunting, taking, capturing, killing, or possessing migratory birds and migratory game birds. The provision incudes any part, nest, or egg of any such bird, or any product composed of any such bird.	Several species of birds including raptors, upland gamebirds, passerines, waterfowl, and shorebirds nest in the area in aspen or conifer stands, sagebrush and grassland habitat, and in riparian habitat along some of the creeks at the mine. Remedial actions will be designed and implemented to avoid harm to migratory birds, their nests, or eggs. Construction schedules will be planned to avoid conflicts with migratory bird activities.	Applicable
	Fish and Wildlife Coordination Act	50 C.F.R. §10.12	Under the Fish and Wildlife Coordination Act, federal agencies involved in actions that will result in the control or structural modification of any natural stream or body of water for any purpose, are required to take action to protect the fish and wildlife resources that may be affected by the action.	Perennial streams within and adjacent to the mine contain several species of fish. The mainstem of Crow Creek has the most diverse fish species assemblages, while Sage Creek has the highest trout biomass. Potentially applicable if remedial action affects any of the natural creeks and streams at the mine or damages any of the fish habitat. Remedial actions will be designed to protect fish and fish habitat.	Applicable
	Endangered Species Act (ESA)	7 U.S.C. 136 16 U.S.C. 460 16 U.S.C. § 1531 et seq. 50 C.F.R. Part 402 40 C.F.R. § 6.302	Federal Agencies are prohibited from jeopardizing threatened and endangered species or adversely modifying habitats essential to their survival. Substantive requirements include prohibition against taking an endangered or threatened species and consultation with the U.S. Fish and Wildlife Service (USFWS) if any threatened or endangered species are present.	May be applicable if remedial action activities jeopardize threatened or endangered species or adversely modify their habitat. The only federally-listed threatened and endangered species in Caribou County is the Canada lynx (*Lynx canadensis*) (FWS 2013). Although potential "linkage" habitat for the lynx is present (Ruediger et al. 2000; USFS 2007), surveys for lynx indicate that this species is not present in the Smoky Canyon Mine area (Maxim 2002, 2004; BLM and USFS 2007). If lynx are observed in the vicinity of the mine during implementation of the final remedy, then the USFWS will be consulted.	Applicable
	Bald and Golden Eagle Protection Act	16 U.S.C. § 668 et seq. 50 C.F.R. 22	Prohibits any person from knowingly, or with wanton disregard, selling, offering to sell, taking, purchasing, transferring, bartering, exporting, importing, or possessing or harming a bald or golden eagle, or any part, nest, or egg thereof without obtaining a permit.	Bald eagles and golden eagles may use the Smoky Canyon Mine area for hunting and/or nesting. These raptors may be expected to nest in aspen or conifer stands in the mid- to higher elevation areas and north and west aspects that receive sufficient moisture to support aspen and conifer stands. Remedial actions will be designed and implemented to avoid harm to bald and golden eagles, their nests, or eggs.	Applicable
Location-Specific	National Historic Preservation Act (NHPA)	54 U.S.C. § 300101 et seq. 36 C.F.R. Parts 60, 63, and 800	The NHPA requires federally funded projects to identify and mitigate impacts of project activities on properties listed on or eligible for listing on the National Register. Section 106 of the NHPA requires that the historic preservation review process balances needs of federal undertaking with effects the undertaking may have on historic properties.	An archaeological team surveyed all areas that might be affected by mining activities at Smoky Canyon (USFS and USGS 1981). A few historic artifacts were found and two sawmills were located in the vicinity of project areas. There are four known historic sites near the lease area (Lander Trail, Crow Creek Wagon Road, Fairview Cutoff, and Oneida Salt Works). Potentially applicable if additional historic sites are found in areas to be disturbed by remedial actions. Impacts of remedial actions will be mitigated in accordance with the NHPA.	Applicable
	Archaeological Resources Protection Act (ARPA)	43 C.F.R. Part 7	Establishes procedures to provide protection for archaeological resources located on public lands. Prohibits any person from excavating, removing, damaging, or otherwise altering or defacing any archaeological resource.	Archaeological resources were investigated for all areas potentially affected by proposed mining activities for the original Environmental Impact Statement (EIS) (USFS and USGS 1981), and an archaeological survey of the borrow areas was conducted in 2017. No archaeological resources were found at the Smoky Canyon Mine. Potentially applicable if archeological resources are found in areas to be disturbed by remedial actions. If archaeological resources are identified during construction of the final remedy, the resources will be protected.	Applicable
	Native American Graves Protection and Repatriation Act (NAGPRA)	25 U.S.C. §§ 3001 to 3013 43 C.F.R. 10	Requires federal agencies and institutions that receive federal funding to return Native American cultural items to lineal descendants and culturally affiliated Indian tribes. It also establishes procedures for the inadvertent discovery or planned excavation of Native American cultural items on federal or tribal lands. These regulations apply to human remains, funerary objects, sacred objects, or objects of cultural patrimony that are indigenous to the continental United States.	Archaeological and historical resources were investigated for all areas potentially affected by proposed mining activities for the EIS (USFS and USGS 1981). The Smoky Canyon MIne area is largely free of cultural resources. Potentially relevant and appropriate if cultural items are identified in USFS lease areas during construction of the final remedy. Any cultural items found will be returned to the tribes.	Relevant and appropriate

TABLE 3-1. Applicable or Relevant and Appropriate Requirements (ARARs)

Type of ARAR	Statute, Regulation, Standard, or Requirement	Citation or Reference	General Description	Site-Specific Comments	Determination
Federal					
Location-Specific	National Environmental Policy Act (NEPA) Protection of Wetlands	40 C.F.R. § 6.302 40 C.F.R. 6 Appendix A	Executive Order 11990 (as amended by Executive Order 12608) was established to implement NEPA and requires agencies conducting certain activities to avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists.	Riparian areas occur along the creeks and streams at the mine and in the vicinity of Hoopes Spring and South Fork Sage Creek Springs. Vegetation in riparian areas is dominated by willows, sedges, and reedgrass. The wetlands protection order may be applicable if remedial actions are planned in areas that contain wetlands and the construction activities planned will impact the wetlands. Compensatory mitigation for loss of wetlands will be developed during remedial design and implemented during construction of the final remedy.	Applicable
	National Forest Management Act	16 U.S.C. §§ 1601 to 1614 36 C.F.R. 219	The Caribou-Targhee Land Use Management Plan establishes multiple use goals and objectives, forest-wide management requirements, and monitoring and evaluation requirements. Establishes direction so that future decisions affecting the Forest will include an interdisciplinary approach to achieve integrated consideration of physical, biological, economic and other sciences.	The management plan provides requirements to maintain and restore National Forest System land and water ecosystems under multiple uses. Requirements of the plan are applicable for any remedial actions.	Applicable
	2003 Revised Forest Plan Caribou National Forest 1997 Revised Forest Plan Targhee National Forest	USFS (2003) USFS (1997)	Provides guidance for all natural resource management activities and establishes management standards within the Caribou-Targhee National Forest in order to sustain watersheds, forests, and rangelands and provide for multiple uses of these lands.	The Smoky Canyon Mine is on National Forest System land in the Caribou-Targhee National Forest and is operated under a Special Use Permit and BLM phosphate leases. Remedial action must take into account the requirements of the Caribou and Targhee Forest Plans.	Applicable
	Federal Land Policy and Management Act of 1976 (FLPMA)	43 U.S.C. §§1701 to 1785	Public lands and their resources are periodically and systematically inventoried and their present and future use is projected through a land use planning process. Public lands are managed for use and protection of the land and its natural resources.	Provisions regarding undue degradation are potentially applicable to actions conducted on the portion of the Smoky Canyon Mine that is on public lands.	Applicable
State of Idaho					
Chemical-Specific	Idaho Water Quality Standards	IDAPA 58.01.02	Idaho water quality standards and wastewater treatment requirements include but are not limited to the following: Administrative policy for protection of waters of the State (.050.02); Antidegradation policy (.051); Mixing zone policy (.060); Violation of water quality standards (.080); Analytical procedures (.090); Surface water use designations and nondesignated surface waters (.100 to .101); Designations of surface waters found within Salmon Basin (.130); General surface water quality criteria (.200); Surface water quality criteria for aquatic life, recreation, water supply, wildlife and aesthetics use designations (.250 to .253); Variances from water quality standards (.260); and Site-specific surface water quality criteria (.275).	The State of Idaho standards and requirements are applicable to surface water bodies at the Site or surface water impacted by the selected remedy.	Applicable
	Site-Specific Selenium Criterion (SSSC)	(Formation and HabiTech 2012) Approved by IDEQ (2018)	Field and laboratory investigations were conducted to examine the effects of selenium on survival and incidence of deformities for brown trout and Yellowstone cutthroat trout. These data were compiled and provided to the Idaho Department of Environmental Quality (IDEQ) as part of the process for developing a site-specific selenium water quality criterion. The brown trout data were also used by USEPA for revising the 2016 National Ambient Water Quality Criterion for Selenium.	The Site-specific selenium criterion for Hoopes Spring, Sage Creek, and Crow Creek near the Smoky Canyon Mine has been approved by IDEQ. This is applicable for sediments and protection of aquatic life until promulgation of the site-specific standards by USEPA.	Applicable
	Idaho Public Drinking Water Systems Rules	IDAPA 58.01.08	Controls and regulates the design, construction, operation, maintenance, and quality control of public drinking water systems to provide a degree of assurance that such systems are protected from contamination and maintained free from contaminants which may injure the health of the consumer.	Hydrogeologic investigations for the RI at Smoky Canyon Mine show that the Thaynes-Dinwoody Formation and Wells Formation produce water. Primary drinking water regulations are applicable if the potential exists for construction of a public drinking water system in the future.	Applicable
	Idaho Ground Water Quality Rule	IDAPA 58.01.11	The Idaho Ground Water Quality Rule (GWQR) establishes minimum requirements for protection of groundwater quality through numerical standards and an aquifer categorization process. The rule addresses protection of groundwater quality, maintaining existing and projected future beneficial uses, categorization of groundwater, establishing groundwater quality standards, and preventing groundwater contamination while allowing for mineral extraction. Section 200 establishes numerical groundwater quality standards. Section 401 describes the process for setting a point of compliance (POC) at which the mine operator must meet the groundwater standards.	State numerical groundwater quality standards are applicable to groundwater at the Site. Groundwater is currently monitored and compared to these standards. Following completion of the remedial actions, a POC may be set in accordance with Section 401 of Idaho's GWQR. Simplot will submit an application to establish a monitored outer boundary where groundwater resources must comply with Idaho's GWQR and will propose monitoring wells as POC and indicator wells. DEQ may determine that additional POC wells are necessary to ensure that there is no injury to current or projected future beneficial uses of groundwater or violation of surface water standards.	Applicable
	Idaho Rules and Standards for Hazardous Waste	IDAPA 58.01.05	Rules adopted pursuant to the Hazardous Waste Management Act (HWMA) establish methods for the identification and listing of hazardous waste, and standards applicable to generators, transporters, and owners and operators of treatment, storage, and disposal facilities.	Numerical standards are potentially applicable to wastes generated by remedial action at the Site. If the selected remedy includes a water treatment system, water treatment residual material or sludge will be tested to determine if the material is hazardous prior to transport or disposal.	Applicable
	Idaho Hazardous Substance Emergency Response Act	Idaho Code §§ 39-7101 to 7115	Facilitates emergency response planning and requires expedient response and/or containment for hazardous substance release in order to protect the health, safety, and welfare of the people of Idaho.	Potentially relevant and appropriate during remedial action construction if there is a release of a hazardous substance.	Relevant and Appropriate

TABLE 3-1. Applicable or Relevant and Appropriate Requirements (ARARs)

Type of ARAR	Statute, Regulation, Standard, or Requirement	Citation or Reference	General Description	Site-Specific Comments	Determination
State of Idaho					
Action-Specific	Idaho Solid Waste Management Rules	IDAPA 58.01.06	Establishes requirements for operation and closure of solid waste and solid waste management facilities. Solid Waste Management Rules and programs administered under the rules are adopted to protect air quality, surface water quality, and groundwater quality.	The Solid Waste Management Rules do not apply to overburden, waste dumps, stockpiles, tailings and other materials associated with phosphate mining (see IDAPA 58.01.06.001.03(b)(iv)). Potentially relevant and appropriate if solid waste management units are constructed as part of the remedy or solid waste is generated during the remedial action.	Relevant and Appropriate
	Idaho Hazardous and Deleterious Material Storage	IDAPA 58.01.02.800	Rules prohibit storage, disposal or accumulation of hazardous and deleterious material adjacent to or in the immediate vicinity of state waters unless adequate measures and controls are provided to ensure that those materials will not enter state waters as a result of high water, precipitation runoff, wind, storage facility failure, accidents in operation, or unauthorized third party activities.	Potentially applicable for chemicals associated with the Hoopes Water Treatment Plant (WTP), which is located in the vicinity of the springs complex upstream of South Fork Sage Creek.	Applicable
	Idaho Surface Mining Act	Idaho Code Title 47, Chapter 15	The Surface Mining Act requires reclamation of the surface of all lands disturbed by mining operations in order to protect public health and wildlife. Section 47-1509 includes procedures for reclamation (i.e., for leveling overburden piles, controlling erosion, preventing surface runoff, abandoning roads, revegetating overburden piles, and reclaiming tailings ponds). Section 47-1510 requires planting of vegetation comparable to the vegetation growing before mining and is required on mined areas.	The final remedy for the mine may include construction of cover systems, abandonment of roads, construction of run-on and runoff controls, and planting of vegetation. Procedures listed in Section 47-1509 should be considered in the selection of reclamation techniques for overburden piles, tailings ponds, haul roads, etc. Seed mixtures for revegetation efforts will be comparable to pre-mining vegetation as described in Section 47-1510.	Relevant and Appropriate
	Idaho Rules for Exploration and Surface Mining	IDAPA 20.03.02	Rules pursuant to the Idaho Surface Mining Act to reclaim the surface of lands and thereby conserve natural resources, protect wildlife and aquatic resources, and reduce soil erosion. Section 20.03.02-140 includes BMPs and reclamation for surface mining operations.	BMPs (e.g., nonpoint source sediment controls, clearing and grubbing, overburden/topsoil, backfilling and grading, and abandonment of tailings impoundments) and reclamation procedures should be considered in the selection of reclamation techniques for pits, overburden areas, and the tailings impoundments.	Relevant and Appropriate
	Idaho Well Construction Standards Rules	IDAPA 37.03.09	Describes requirements for well construction and abandonment. Rule 25 pertains to construction of cold water wells. Monitoring and remediation wells must be constructed and maintained in a manner that prevents waste or contamination. Rules state that when a monitoring well is no longer useful or needed, it must be decommissioned in accordance with Rule 25 Subsection 025.16.	There are 24 active groundwater monitoring wells at the Site. Some of these wells may be targeted for abandonment or new wells may be installed as part of the remedial action. Well construction/abandonment procedures must be followed and materials prescribed under Rule 25 must be used during construction or abandonment of groundwater monitoring wells.	Applicable
	Idaho Uniform Environmental Covenants Act	Idaho Code Title 55 Chapter 30 Sections 55-3001 to 3015	Describes requirements for environmental covenants which include a legal description of the property subject to the covenant, a description of the activity and use limitations on the property, an identification of every holder, and the name and location of any administrative record for the environmental response project reflected in the covenant.	Potentially applicable for portions of the Smoky Canyon Mine where remedial actions are implemented that are on private lands (i.e., Sage Valley).	Applicable
	Rules for the Control of Air Pollution in Idaho and Rules for Control of Fugitive Dust	IDAPA 58.01.01	These rules provide for the control of air pollution in Idaho. Rules 650 to 651 require that precautions be taken to prevent the generation of fugitive dust.	Potentially relevant and appropriate if remedial actions generate fugitive dust. Precautions appropriate to construction for remedial actions may include the use of water or chemicals, the application of dust suppressants, and/or covering of dump trucks used for hauling soils.	Relevant and Appropriate
	Rules Governing Point Source Discharges and Point Source Wastewater Treatment Requirements	IDAPA 58.01.02.400--401	Provides limits and restrictions on temperature and turbidity for point source discharges to waters of the state. Under Rule 401, the wastewater or discharge must not affect the temperature of the receiving or downstream waters so as to interfere with designated beneficial uses. Rule 401 also requires that the wastewater or discharge must not increase the turbidity of the receiving or downstream waters more than 5 Nephelometric Turbidity Units (NTU) over background when background is 50 NTU or less.	Potentially applicable for remedial actions that result in a point source discharge such as discharge from the Hoopes WTP to the Hoopes Spring drainage before it joins South Fork Sage Creek. Effluent and surface water downstream must comply with these limits and restrictions.	Applicable
	Idaho Stream Channel Alteration Rules	IDAPA 37.03.07	State of Idaho rules for alteration of stream channels that include minimum standards for construction to prevent alterations that will be a hazard to a stream channel and its environment. Requires a joint permit with the Idaho Department of Water Resources (IDWR), Idaho Department of Lands (IDL), and the US Army Corps of Engineers (USACE) under the Stream Protection Act.	The final remedy will be designed to minimize or avoid impacts to stream channels. For areas where construction does alter, modify, relocate, or change the natural existing shape of the channel or change the direction of flow of water in the stream channel, minimum standards for construction (e.g., construction procedures, temporary structures, dumped rock riprap, culverts, etc.) shall apply. Potentially applicable to prevent alterations that will be a hazard to a stream channel and its environment during remedial actions.	Applicable
	Idaho Classification and Protection of Wildlife Rule	IDAPA 13.01.06	Rules establish the classification and protection of wildlife including big game animals, upland game animals, game birds, game fish, fur-bearing animals, threatened or endangered species, protected nongame species, and predatory wildlife. State of Idaho law prohibits taking or possessing protected nongame and threatened or endangered species. Game species may be taken in accordance with Idaho law and rules established by the Idaho Fish and Game Commission. Idaho law and rules are enforced by the Idaho Department of Game and Fish (IDGF). Wildlife species classified as unprotected and predatory may be taken in any amount at any time.	Big game animals (deer, elk, black bear, mountain lion), migratory game birds (duck, goose, dove), upland birds (partridge, grouse), upland game/furbearers (rabbit, marten, mink, weasel, red fox, skunk, badger, bobcat, coyote), and game fish (trout, whitefish) are present in and around the mine and may be taken in accordance with hunting and fishing rules established by IDGF. Protected nongame fish (blue-head sucker) and any threatened or endangered species (lynx) may not be harvested or possessed. Monitoring programs for wildlife currently conducted at the Smoky Canyon Mine in conjunction with the IDFG deal with big game special-use areas and sage grouse leks. Remedial action must be designed and implemented to comply with these rules to protect wildlife and threatened or endangered species.	Applicable
	Idaho Protection of Animals and Birds	Idaho Code Title 36, Chapter 11	Idaho law prohibits taking of wildlife, birds or fur-bearing animals and declares exceptions. For the protection of animals and birds, it is unlawful to hunt from motorized vehicles or aircraft or hunt using artificial light. Property owners have the right to control, trap, or remove any wild animal damaging private property.	Remedial action must be designed and implemented to comply with these rules with restrictions on the taking of wildlife, protection of wildlife, and control of predators.	Applicable

TABLE 3-1. Applicable or Relevant and Appropriate Requirements (ARARs)

Type of ARAR	Statute, Regulation, Standard, or Requirement	Citation or Reference	General Description	Site-Specific Comments	Determination
Location-Specific	Idaho Preservation of Historical Sites	Idaho Statutes Title 67, Chapters 46 and 41	Authorization to preserve historical, archeological, architectural, and cultural heritage. Provides for designation as historic property if property meets criteria established for inclusion in the national register of historic places. Historic property is any building, structure, area, or site that is significant in the history, architecture, archaeology, or culture of the State of Idaho.	An archaeological team surveyed all areas that might be affected by mining activities at Smoky Canyon (USFS and USGS 1981). A few historic artifacts were found and two sawmills were located in the vicinity of project areas. There are four known historic sites near the lease area (Lander Trail, Crow Creek Wagon Road, Fairview Cutoff, and Oneida Salt Works). Potentially applicable if additional historic sites are found in areas to be disturbed by remedial actions (i.e., borrow areas).	Applicable
	Rules for Fences in General	Idaho Code Title 35, Chapter 1	Provides specifications for lawful fences in the State of Idaho and requirements for erection of partition fences, care of fences, and establishment of gates. Fences must not be less than 4-1/2 feet high and the bottom board, rail, pole, or wire of the fence must not be more than 20 inches above the ground.	Fences are currently in place in lower South Fork Sage Creek to restrict access by wildlife. Potentially applicable if fencing is required as part of the selected remedy. Fences installed for the remedy would have to meet state specifications.	Applicable
	Idaho Stream Channel Alteration Rules	IDAPA 37.03.07	State of Idaho rules for alteration of stream channels that include minimum standards for construction to prevent alterations that will be a hazard to a stream channel and its environment. Requires a joint permit with the Idaho Department of Water Resources (IDWR), Idaho Department of Lands (IDL), and the US Army Corps of Engineers (USACE) under the Stream Protection Act.	The design of the final remedy will be developed to minimize or avoid impacts to stream channels. For areas where construction does alter the natural existing shape of the channel or change the direction of flow of water in the stream channel, minimum standards for construction (e.g., construction procedures, temporary structures, dumped rock riprap, culverts, etc.) shall apply. Potentially applicable to prevent alterations that will be a hazard to a stream channel and its environment.	defer to Action-specific ARAR

TABLE 3-2. Criteria or Guidance To Be Considered (TBCs)

Type of TBC	Statute, Regulation, Requirement, or Reference	Citation or Reference	Description	Site-Specific Comments	Determination
Chemical-Specific	National Secondary Drinking Water Regulations	42 U.S.C 300g-1 40 C.F.R. Part 143	Establishes secondary drinking water regulations (secondary MCLs) pursuant to Section 1412 of the Safe Drinking Water Act, as amended. These regulations control contaminants in drinking water that primarily affect the aesthetic qualities relating to public acceptance of drinking water. At considerably higher concentrations of these contaminants, health implications may exist as well as aesthetic degradation. The regulations are not Federally enforceable but are intended as guidelines for public water systems.	Hydrogeologic investigations for the Remedial Investigation (RI) at the Smoky Canyon Mine show that the Thaynes-Dinwoody Formation and Wells Formation produce water. Groundwater from the Culinary Well is used as a private drinking water supply at the mIne. Secondary drinking water regulations are to be considered if groundwater beneath the Site will be used to supply public water systems.	TBC
	Idaho Secondary Drinking Water Regulations	IDAPA 58.01.08.400	Section 400 of the Idaho Department of Environmental Quality (IDEQ) Rules for Public Drinking Water Systems establishes secondary MCLs (as defined in 40 C.F.R. Part 143) for public water systems. These regulations control contaminants in drinking water that primarily affect the aesthetic qualities relating to public acceptance of drinking water. At considerably higher concentrations of these contaminants, health implications may exist as well as aesthetic degradation. The regulations are not Federally enforceable but are intended as guidelines for public water systems.	Hydrogeologic investigations for the RI at Smoky Canyon Mine show that the Thaynes-Dinwoody Formation and Wells Formation produce water. Groundwater from the Culinary Well is used as a private drinking water supply at the mIne. Secondary drinking water regulations should be considered if groundwater beneath the Site will be used to supply public water systems.	TBC
	Idaho Ground Water Quality Rule	IDAPA 58.01.11	The Idaho GWQR establishes minimum requirements for protection of groundwater quality through numerical standards.	The State numerical groundwater quality standard for arsenic is to be considered for areas of the Site with arsenic contamination in groundwater.	TBC
	USEPA Regional Screening Levels (RSLs)	USEPA (2018) [1]	US Environmental Protection Agency (USEPA) establishes acceptable risk levels for individual contaminants to protect human health drinking water uses at the 1×10^{-6} level for individual carcinogens or a hazard quotient (HQ) of 1 for non-carcinogens. The RSLs are risk-based concentrations derived from standardized equations combining exposure information assumptions with USEPA toxicity data.	RSLs are to be considered if groundwater or surface water is used as drinking water. These standards are only for carcinogenic contaminants for which there are no maximum contaminant level goals (MCLGs) or maximum contaminant levels (MCLs) established.	TBC
	Sediment Quality Assessment Guidelines (SQAGS)	McDonald et al. (2003) [2]	Sediment quality assessment guidelines (SQAGS) are numerical guidelines for assessing the potential for adverse biological effects associated with exposure to contaminated sediments. Both threshold effect concentrations (TEC) and probable effect concentrations (PEC) are included in the guidelines. SQAGS are used to conduct sediment quality assessments and to support defensible sediment management decisions.	The Site Specific Ecological Risk Assessment (SSERA) for the Smoky Canyon Mine used the SQAGS threshold effect concentration values as initial risk screening values for sediment concentrations at the Site. In the end, the SSERA stated that any risk conclusions for selenium in aquatic environments should be made based on concentrations in fish tissues. If sediment in streams or other aquatic habitats at the mine is impacted by remedial actions, then the SQAGS are to be considered. Site-specific selenium criterion (SSSC) for Hoopes Spring, Sage Creek, and Crow Creek near the Smoky Canyon Mine have been approved by IDEQ. Although USEPA approval of these SSSC is pending, these site-specific standards are a chemical-specific ARAR for sediments and protection of aquatic life until promulgation of the SSSC.	TBC
	NOAA Freshwater Sediment Benchmarks	NOAA (2008) [3]	The NOAA Screening Quick Reference Tables (SQuiRTs) are screening concentrations or benchmarks for freshwater sediments. The benchmarks are for preliminary screening purposes and do not constitute clean-up levels.	NOAA SQuiRT concentration values were used in the SSERA for the Smoky Canyon Mine as secondary risk screening values for sediment concentrations. The values for selenium are conservative. In the end, the SSERA stated that any risk conclusions for selenium in aquatic environments should be made based on concentrations in fish tissues. If sediment in streams or other aquatic habitats at the mine is impacted by remedial actions, then the SQuiRTs are to be considered.	TBC
	Proposed Selenium Benchmarks for Freshwater Sediment	Lemly (2002) [4] Vanderveer and Canton (1997) [5]	Two different studies (Lemly 2002; Vanderveer and Canton 1997) arrived at two different potential protective levels in sediments. Neither is quantitatively derived nor based on effects to benthic macroinvertebrates.	The range of 2 to 4 milligram per kilogram dry weight (mg/kg dw) provides for a screening level for selenium in sediments. These values do not constitute effects thresholds or clean up values. Background should be considered in the context of these values. More specifically, because fish are a more sensitive indicator of effects for selenium in the aquatic environment, tissue concentrations for fish should be considered as the threshold values for effects and potential cleanup.	TBC

TABLE 3-2. Criteria or Guidance To Be Considered (TBCs)

Type of TBC	Statute, Regulation, Requirement, or Reference	Citation or Reference	Description	Site-Specific Comments	Determination
Action-Specific	American Indian Religious Freedom Act (AIRFA) Religious Freedom Restoration Act (RFRA)	42 U.S.C. § 1996 et seq. H.R. 4155 42 U.S.C. §§ 2000bb-200bb-4	The AIRFA protects and preserves the traditional religious rights and cultural practices of Native Americans. These rights include access of sacred sites, repatriation of sacred objects held in museums, freedom to worship through ceremonial and traditional rites, and use and possession of objects considered sacred. The Act, as amended, provides for the management of federal lands in a way that does not frustrate the traditional religions and religious purposes of Native Americans. The RFRA protects religious practices that are substantially burdened by governmental actions.	The Shoshone-Bannock Tribes is a federally recognized sovereign nation located on the Fort Hall Reservation in southeast Idaho. The Smoky Canyon Mine and all public lands in the vicinity of the mine may be used for Tribal ceremonial activities consistent with the Shoshone-Bannock Tribe treaty-reserved rights. These rights are to be considered before any remedial actions are implemented at the Site.	TBC
	Idaho Nonpoint Source Management Plan	IDAPA 58.01.02.350 IDEQ (2015)	Idaho's Nonpoint Source (NPS) Management Plan, developed as required by USEPA under Section 319 of the Clean Water Act, provides guidance to protect or restore (where possible) the beneficial uses of the State's surface water and groundwater. The plan includes both groundwater and surface water protection programs, which are coordinated and administered by Idaho DEQ. Water quality goals include monitoring and assessing water quality conditions to determine compliance with standards and support of beneficial use.	Surface water and groundwater at Smoky Canyon Mine are monitored to assess water quality conditions and determine compliance with aquatic water quality criteria and groundwater standards. The NPS Management Plan provides guidance to be considered under the various monitoring programs at the mine.	TBC
	Surface Mine and Reclamation Plan Smoky Canyon Project	Idaho Code Title 47, Chapter 15 Simplot (1981)	The Surface Mine and Reclamation Plan provides Simplot's proposal to develop the Smoky Canyon phosphate lease I-012890 as an open pit mine. The plan includes exploration drilling to delineate the ore body within each mine panel, development drilling to be conducted in conjunction with production to resolve structure problems, and a reclamation program to optimize surface mine rehabilitation.	The Surface Mine and Reclamation Plan is to be considered during mining and reclamation activities. The sequence of mine panel development began in accordance with the preferred approach in the mine plan, but has changed over time as the needs of the mine changed. The reclamation plan at the Smoky Canyon Mine is conducted concurrently with development to minimize the amount of disturbed acreage and facilitate reclamation of waste disposal sites and reestablishment of cover and forage.	TBC
	Idaho Department of Lands (IDL) Best Management Practices for Mining in Idaho	IDL (1992) [6]	The IDL handbook presents best management practices (BMPs) for surface dredge and placer mining which help minimize nonpoint source water quality impacts from mining as well as promote and enhance the natural recovery of mined sites. Identification of BMPs is mandated by Section 319 of the Clean Water Act.	Although not required by statute, BMPS are recommended for use both during and after mining to minimize water quality impacts from increased sedimentation to surface waters from areas cleared for mining, roads built for access to the site, stockpiles of topsoil, ore, and waste rock, and stream channel alterations. BMPs are to be considered during the implementation of remedial actions.	TBC
	Catalog of Stormwater Best Management Practices for Idaho Cities and Counties	IDEQ (2005)	The catalog provides technical guidance for construction site design and the selection of stormwater BMPs. The objective of stormwater management is to minimize damage to natural resources, minimize the amount of sediment and other contaminants in runoff, and preserve the stability of stream corridors.	Procedures contained in the Catalog of BMPs for Idaho to control erosion and sediment during and after construction are to be considered during implementation of the final remedy.	TBC
Location-Specific	Considering Wetlands at CERCLA Sites Guidance	OSWER 9280.03 (May 1994)	Provides guidance when considering the potential impacts of remedial actions on wetlands in order to protect wetlands under the substantive requirements of the Floodplain Management Executive Order (EO 11988) and the protection of Wetlands Executive Order (EO 11990).	Riparian areas occur along the creeks and streams at the mine and in the vicinity of Hoopes Spring and South Fork Sage Creek Springs. Vegetation in riparian areas is dominated by willows, sedges, and reedgrass. The wetlands protection order may be applicable if remedial actions are planned in areas that contain wetlands and the construction activities planned will impact the wetlands. Prior to initiating any action that might impact wetlands, mitigation measures such as impact avoidance, impact minimization, and compensatory mitigation should be considered.	TBC
	Bureau of Land Management Record of Decision (ROD) and Approved Pocatello Resource Management Plan (RMP) with amendments	BLM (2012)	RMP ensures that impacted lands will be rehabilitated to accommodate productive, post-mining land uses by establishing multiple use goals and objectives, BLM management and monitoring and evaluation guidelines. Establishes direction so that future decisions affecting BLM managed lands will include an interdisciplinary approach to achieve integrated consideration of physical, biological, economic and other sciences. Provides the direction for how the public lands are to be managed/administered by the Pocatello Field Office.	The Pocatello Field Office RMP provides guidelines for management of reclamation activities to ensure containment and control of selenium and other contaminants. The guidelines provided in the plan are to be considered during remedial actions.	TBC
	Selenium Area-Wide Investigation Area-Wide Risk Management Plan	IDEQ (2004)	The Area-Wide Investigation (AWI) required IDEQ to develop an Area-Wide Risk Assessment and Risk Management Plan. The Area-Wide Risk Management Plan (AWRMP) provides discretionary guidance to assist in mine-specific risk management under CERCLA. Specific removal action goals, objectives, and action levels presented in the plan were developed to assist in focusing resources, identifying releases and areas of concern, and making decisions.	The Area-Wide removal action goals and objectives In the AWRMP target the protection of surface water, groundwater, wildlife, and multiple beneficial uses in the Southeast Idaho phosphate resource area. These goals and objectives are to be considered in making decisions about site-specific activities at the Smoky Canyon Mine.	TBC

Notes:

1 - U.S. Environmental Protection Agency Regional Screening Levels (RSLs) accessed at https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

2 - MacDonald, D.D., C.G. Ingersoll, D.E. Smorong, R.A. Lindskoog, G. Sloane, and T. Biernacki. 2003. Development and Evaluation of Numerical Sediment Quality Assessment Guidelines (SQAGs) for Florida Inland Waters. Florida Department of Environmental Protection, Tallahassee, FL.

3 - National Oceanic and Atmospheric Association (NOAA). 2008. Screening Quick Reference Tables (SQuiRTs). NOAA Office of Response and Restoration Division, NOAA OR&R Report 08-1, Seattle, WA. Available at http://response.restoration.noaa.gov/book_shelf/122_NEW-SQuiRTs.pdf.

4 - Lemley, A.D. 2002. Selenium assessment in aquatic ecosystems. A Guide for Hazard Evaluation and Water Quality Criteria. Springer-Verlag, New York, NY.

5 - Vanderveer, W.D., and S.P. Canton. 1997. Selenium Sediment Toxicity Thresholds and Derivation of a Water Quality Criteria for Freshwater Biota of Western Streams. Environmental Toxicology and Chemistry. Vol 16, No. 6. 1260-1268.

6 - Idaho Department of Lands (IDL) in conjunction with Other State and Federal Agencies through The Idaho Mining Advisory Committee. 1992. Best Management Practices for Mining in Idaho.

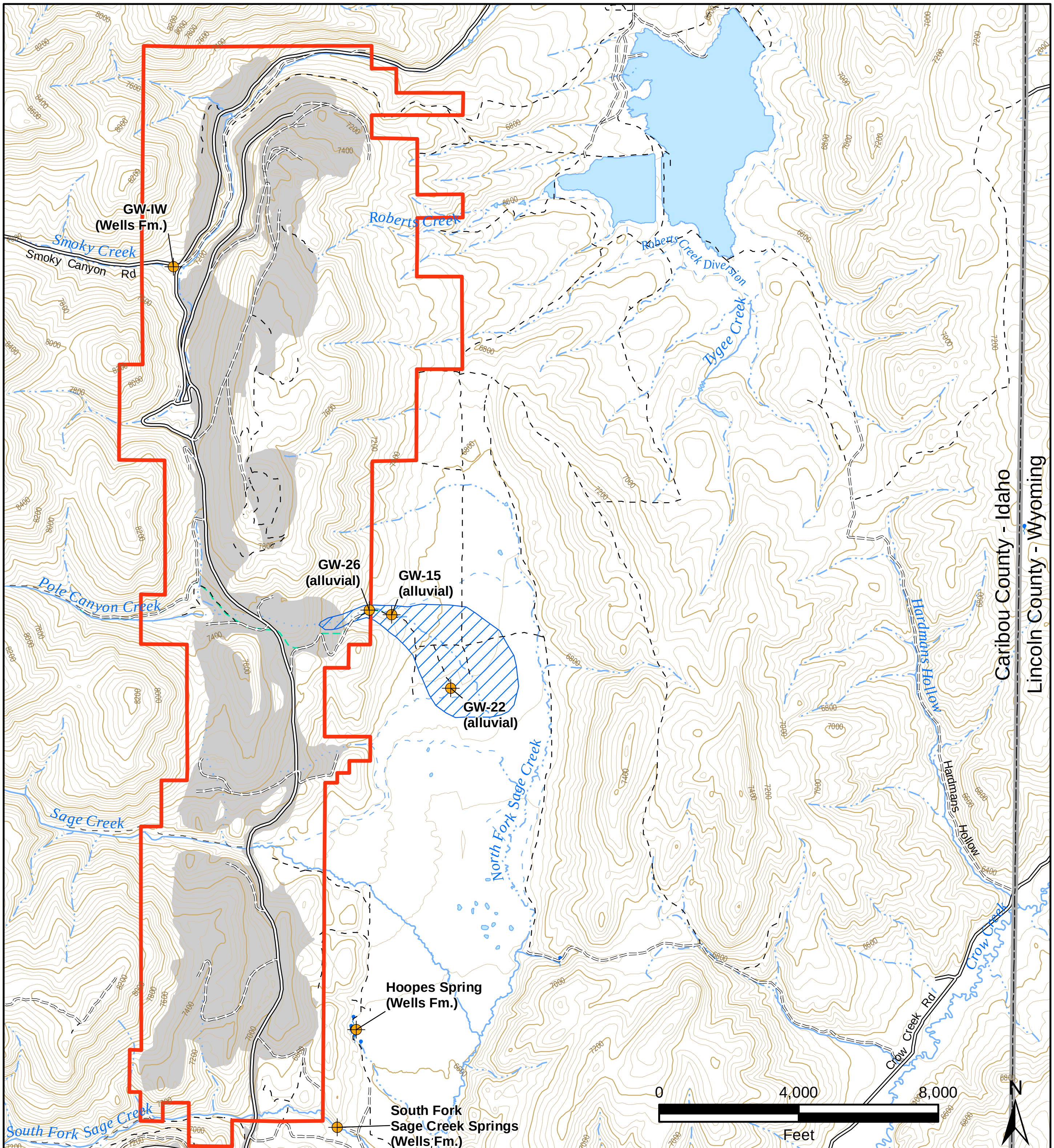
TABLE 3-3. Preliminary Remediation Goals

Remedial Action Objective (RAO)	Preliminary Remediation Goal (PRG)
Non-Regulated Surface Water	
Reduce or eliminate unacceptable risks to human receptors from ingestion of non-regulated surface water (seeps and detention ponds) due to arsenic.	MCL 0.01 mg/L Arsenic
Groundwater	
Prevent future use of alluvial or Wells Formation groundwater with arsenic or selenium concentrations above MCLs as a drinking water source.	MCL 0.05 mg/L Selenium MCL 0.01 mg/L Arsenic
Reduce or eliminate concentrations of arsenic and selenium in contaminated Wells Formation and alluvial groundwater to below MCLs within a reasonable time frame given the circumstances of the Site.	MCL 0.05 mg/L Selenium MCL 0.01 mg/L Arsenic
Reduce or eliminate loading of selenium from groundwater to surface water so that it does not result in concentrations that represent an unacceptable risk to aquatic life in the lower Sage Creek and Crow Creek watersheds.	Risk-Based Site-Specific Standard for Brown Trout Whole body - 14.14 mg/kg Selenium Egg - 20.5 mg/kg Selenium (average values)
Reduce or eliminate loading of selenium from groundwater to surface water so that it does not result in concentrations above the Aquatic Water Quality Standard in the lower Sage Creek and Crow Creek watersheds.	Aquatic Water Quality Standard 0.005 mg/L Selenium (at any location in the watersheds)
Regulated Surface Water	
Reduce selenium concentrations in lower Sage Creek and Crow Creek watersheds to below levels that pose unacceptable risks for aquatic life.	Risk-Based Site-Specific Standard for Brown Trout Whole body - 14.14 mg/kg Selenium Egg - 20.5 mg/kg Selenium (average values)
Reduce selenium concentrations in lower Sage Creek and Crow Creek watersheds to below the Aquatic Water Quality Standard.	Aquatic Water Quality Standard 0.005 mg/L Selenium (at any location in the watersheds)
Soils/Overburden	
Reduce or eliminate unacceptable risks to future Seasonal Ranchers from ingestion of beef (livestock grazing on ODAs) as the primary contributor of cancer risk, due to arsenic concentrations (calculated on a Site-wide basis) for soil.	Risk-Based Level 11.5 mg/kg Arsenic (Site-wide average concentrations in surface soil)

Notes:

mg/L - milligrams per liter

mg/kg - milligrams per kilogram



Legend

- Groundwater Monitoring Locations Exceeding Selenium MCL (0.05 mg/L)
- Minor Road
- Unimproved Road
- Trail (4WD)
- Trail (Other than 4WD)
- Perennial Stream
- Intemittent Stream
- Canal Ditch
- Historic Flow Path
- Pipeline
- Index Contour (200 ft)
- Intermediate Contour (40 ft)
- Lake/Pond
- Mine Disturbance Area
- Estimated Extent of Affected Alluvial Groundwater
- Lease Area

MCL = Maximum Contaminant Level (0.05 mg/L)

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FIGURE 3-1

EXCEEDANCES OF SELENIUM MCL IN GROUNDWATER

DATE: JULY 2018

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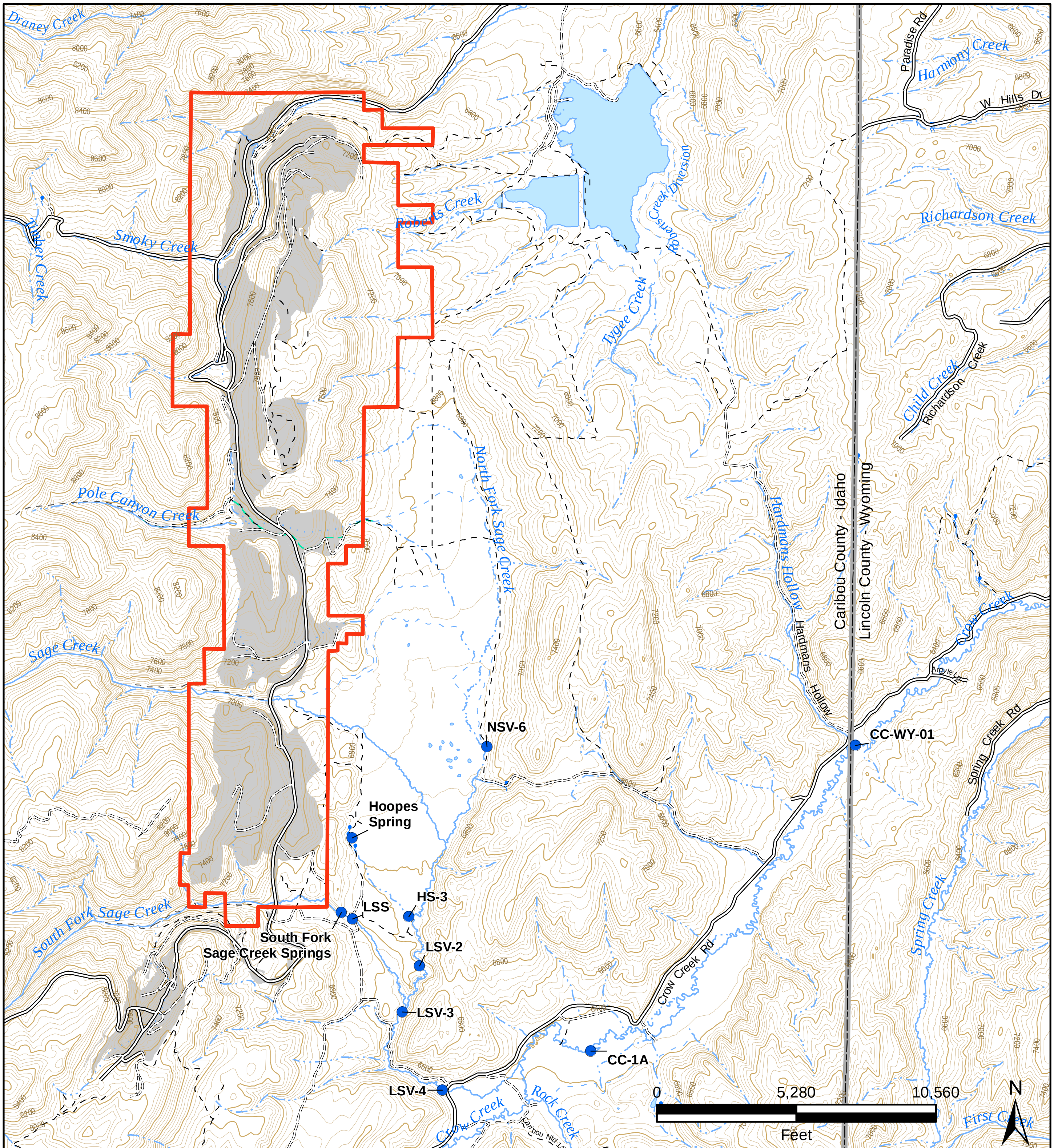

Legend

- Surface Water Monitoring Locations Exceeding State of Idaho Surface Water Quality (Selenium) Criteria for Aquatic Life (0.005 mg/L)
- Minor Road
- Unimproved Road
- Trail (4WD)
- Trail (Other than 4WD)
- Perennial Stream
- Intemittent Stream
- Canal Ditch
- Historic Flow Path
- Pipeline
- Index Contour (200 ft)
- Intermediate Contour (40 ft)
- Lake/Pond
- Mine Disturbance Area
- Lease Area

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FIGURE 3-2

EXCEEDANCES OF SELENIUM CRITERION IN SURFACE WATER

DATE: JULY 2018
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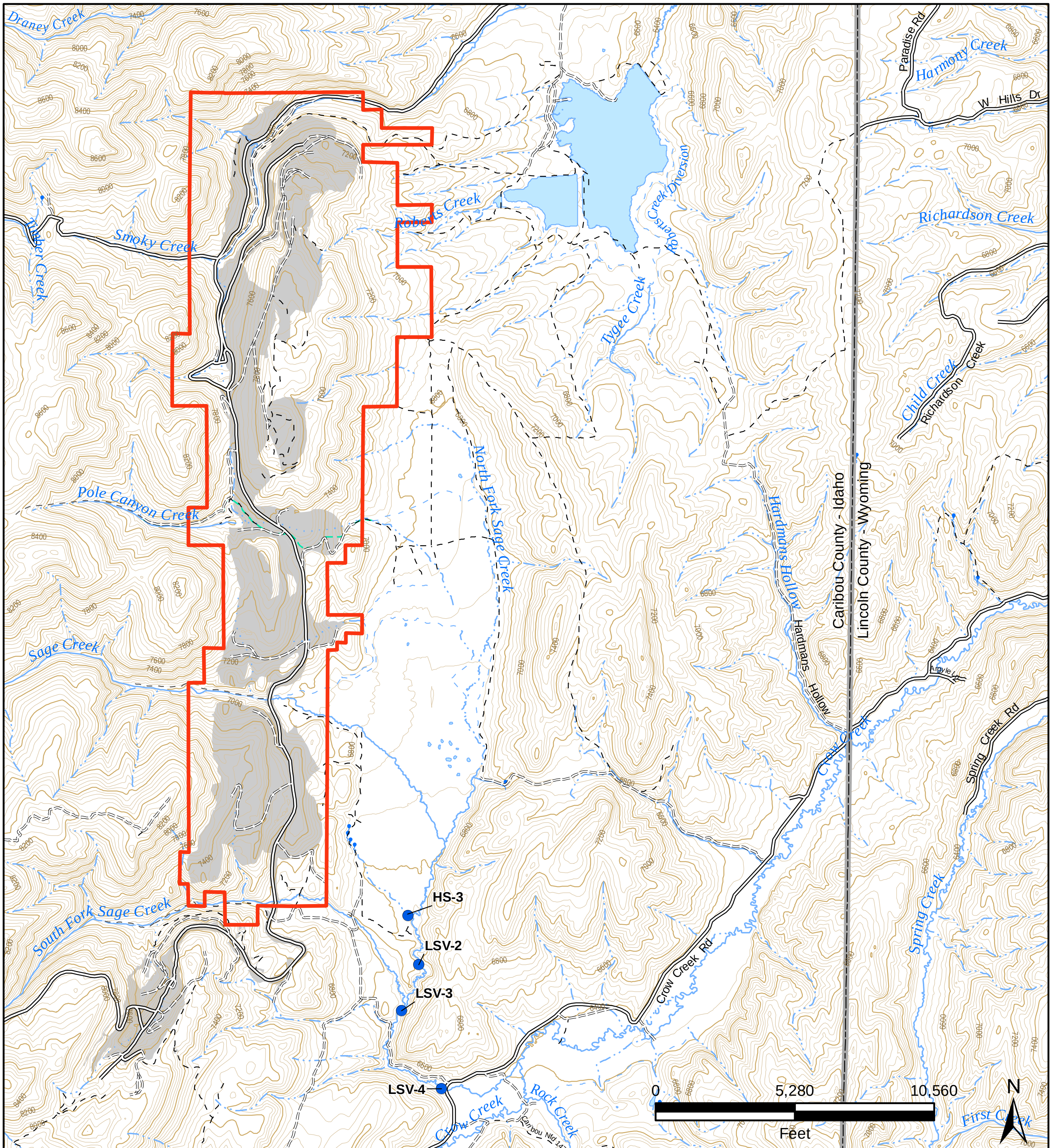

Legend

Surface Water Monitoring Locations with Elevated Selenium Risk to Aquatic Biota (Whole Body Tissue >13.2 mg/kg [USEPA-Derived] and >14.14 mg/kg dry weight [Simplot-Derived])	Perennial Stream	Index Contour (200 ft)
	Intermittent Stream	Intermediate Contour (40 ft)
	Canal Ditch	Lake/Pond
	Historic Flow Path	Mine Disturbance Area
Minor Road	Pipeline	Lease Area
Unimproved Road		
Trail (4WD)		
Trail (Other than 4WD)		

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FIGURE 3-3

ELEVATED SELENIUM RISK TO AQUATIC BIOTA (WHOLE BODY FISH TISSUE)

DATE: JULY 2018

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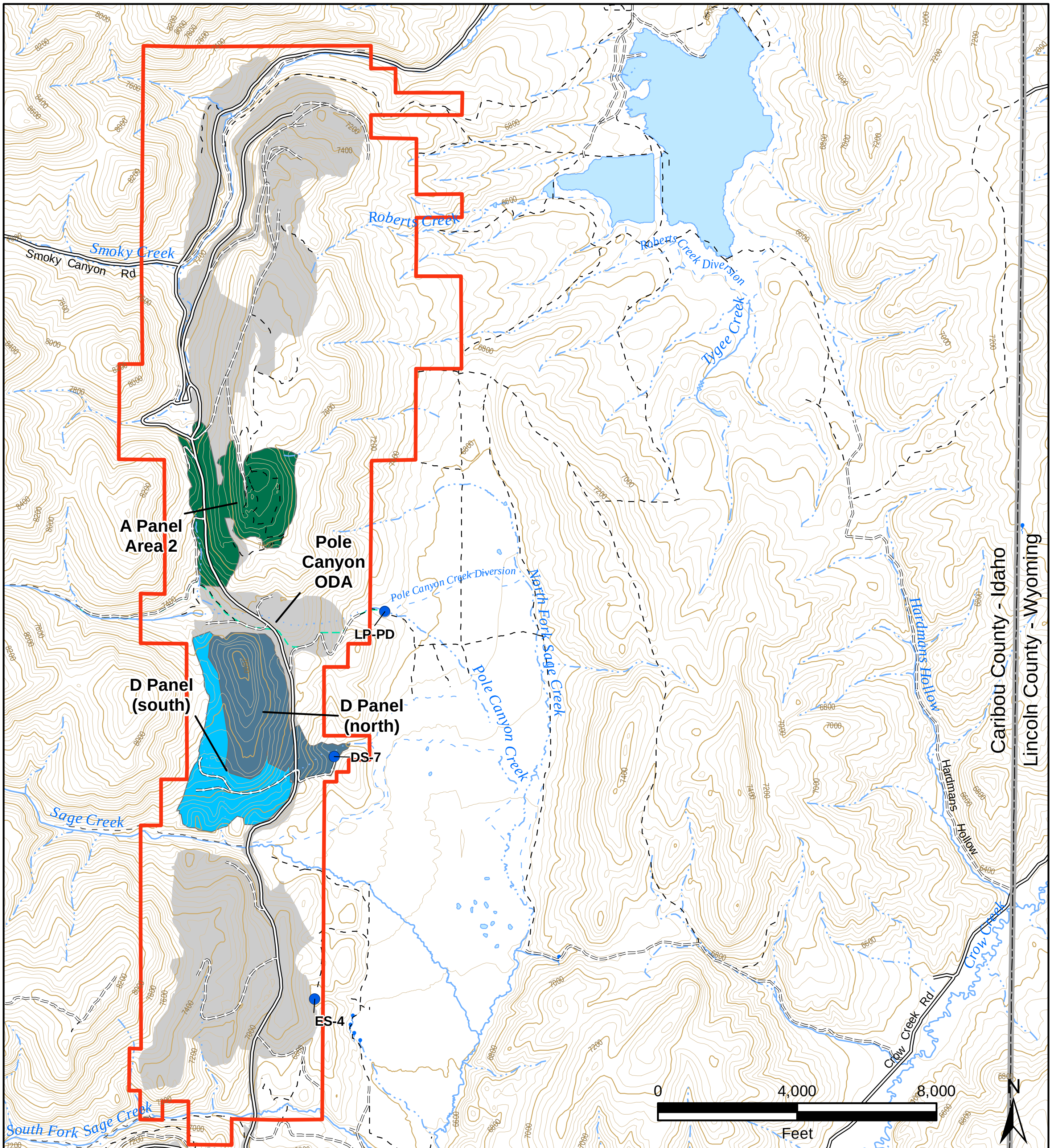

Legend

- Monitoring Locations with Elevated Selenium Risk
- Minor Road
- Unimproved Road
- Trail (4WD)
- Trail (Other than 4WD)
- Perennial Stream
- Intemittent Stream
- Canal Ditch
- Historic Flow Path
- Pipeline
- Lease Area
- Lake/Pond
- Mine Disturbance Area

Sampling Areas with Elevated Selenium Risk

- Panel A (Area 2)
- Panel D (north)
- Panel D (south)

Note: Selenium risk to terrestrial biota on the Pole Canyon ODA has been eliminated as a result of the Pole Canyon ODA NTCRA cover constructed in 2015.

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FIGURE 3-4

ELEVATED SELENIUM RISK TO TERRESTRIAL BIOTA FROM SOIL AND BIOTIC MEDIA

DATE: JULY 2018

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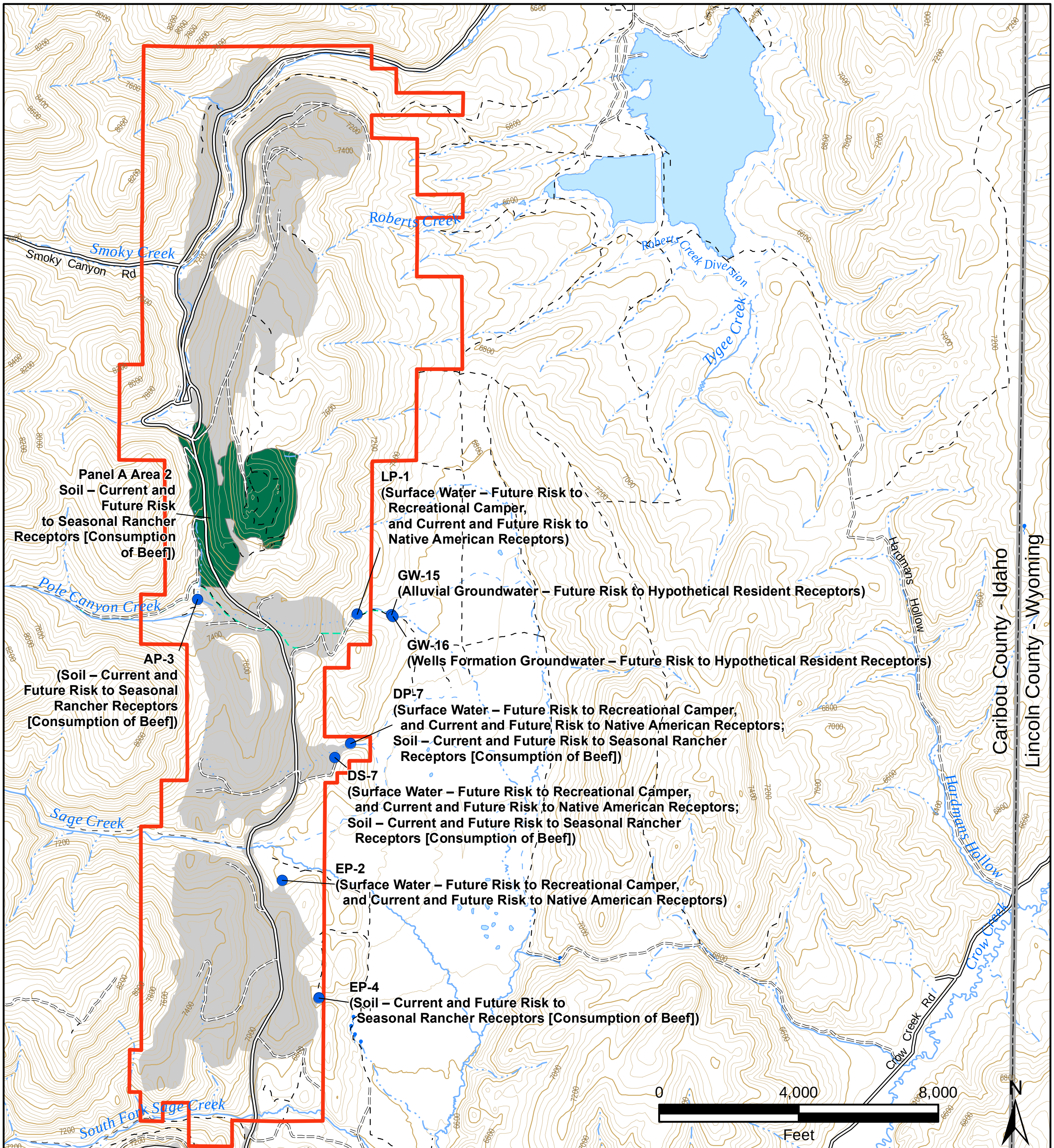

Legend

- Monitoring Locations with Elevated Arsenic Risk
- Minor Road
- Unimproved Road
- Trail (4WD)
- Trail (Other than 4WD)
- Index Contour (200 ft)
- Intermediate Contour (40 ft)
- Perennial Stream
- Intemittent Stream
- Canal Ditch
- Historic Flow Path
- Pipeline
- Lease Area
- Lake/Pond
- Mine Disturbance Area

Sampling Area with Elevated Arsenic Risk

- Panel A (Area 2)

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FIGURE 3-5

ELEVATED ARSENIC RISK TO HUMAN RECEPTORS

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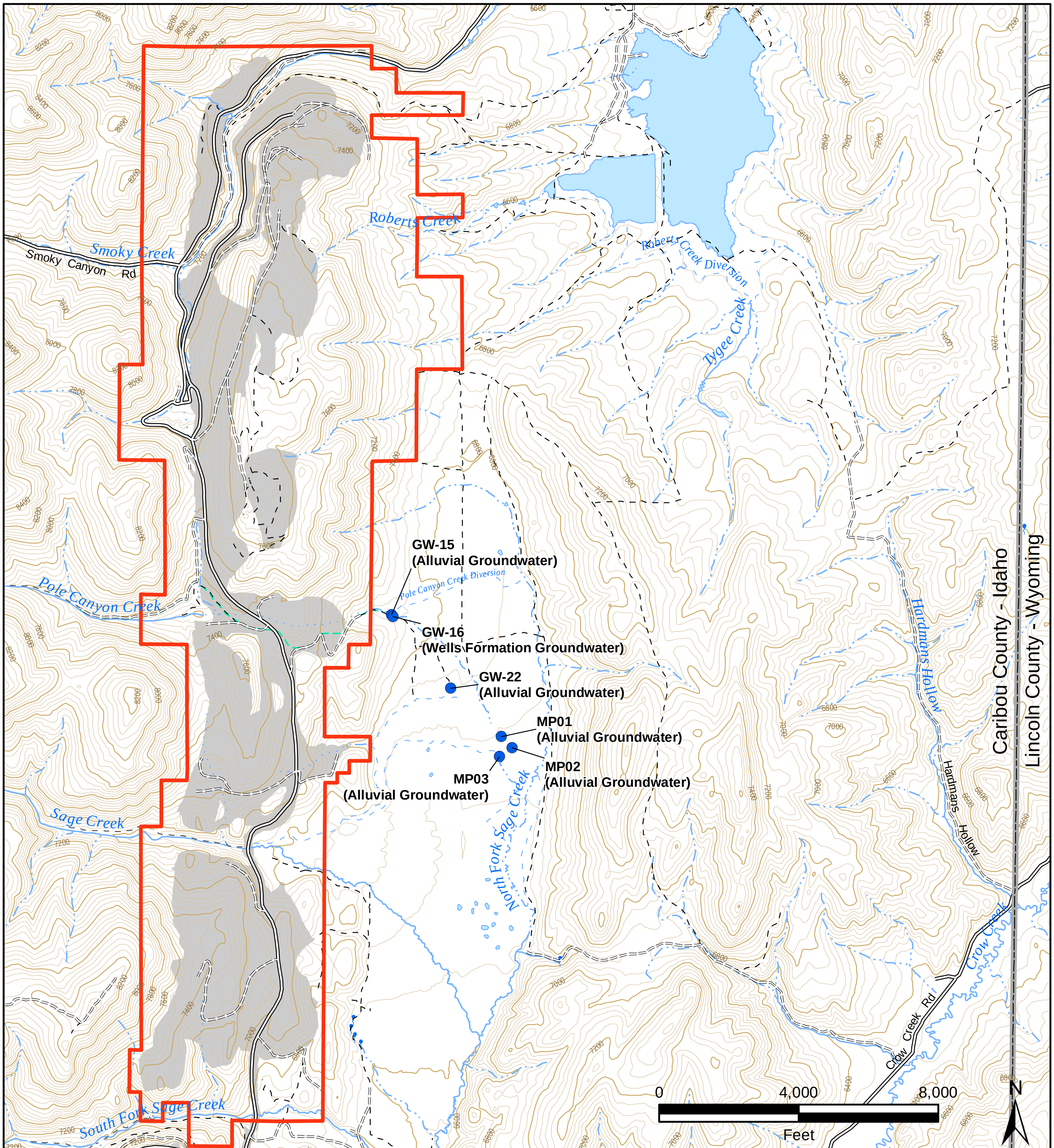

Legend

●	Monitoring Locations with Future Elevated Selenium Risk		Perennial Stream		Lake/Pond
	Minor Road		Intermittent Stream		Mine Disturbance Area
	Unimproved Road		Canal Ditch		Lease Area
	Trail (4WD)		Historic Flow Path		
	Trail (Other than 4WD)		Pipeline		
	Index Contour (200 ft)				
	Intermediate Contour (40 ft)				

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FIGURE 3-6

FUTURE ELEVATED SELENIUM DRINKING WATER RISK TO HYPOTHETICAL RESIDENT HUMAN RECEPTORS

DATE: JULY 2018
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FOR: ACK

FORMATION ENVIRONMENTAL

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4.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

This section identifies GRAs, remedial technologies, and process options that are potentially implementable to address the RAOs identified in Section 3 for the contaminated media and exposure pathways of concern. GRAs are general categories of remedial activities (e.g. no action, institutional controls, containment, source controls, flow controls and routing, removal/disposal, and treatment) that may be used, either singly or in combination, to satisfy RAOs. Remedial technologies and process options are more specific applications of the GRAs.

This section presents the initial screening of remedial technologies and process options in accordance with the NCP to retain representative technologies and process options that can be further screened by media, as discussed in Section 5.

The identification and screening process consists of the following general steps:

- Identify the contaminants and affected environmental media that pose risks to human health and the environment and group these into a category or categories of contaminated media (e.g., solids and soils and groundwater and surface water) for FS evaluation.
- Identify GRAs for the contaminated environmental media that will satisfy the RAOs.
- Compile remedial technologies and process options for each GRA that are potentially viable for remediation of the contaminated environmental media.
- Screen the remedial technologies and process options with respect to technical implementability for the contaminated media at the site. Technologies and process options that are not technically implementable relative to the contaminated media are eliminated from further consideration in this FS.
- Evaluate and screen the retained remedial technologies and process options with respect to effectiveness, ease of implementability, and relative cost. Technologies and process options that have low effectiveness, low implementability, or high cost are eliminated from further consideration in this FS.
- Perform a final screen of retained remedial technologies/process options by media and select a representative process option for each technology type in accordance with September 8, 2017 Agency comments (USFS 2017) on the Revised Draft FSTM#1, that will be used for development, screening, and detailed analysis of alternatives in FSTM#2.

The remainder of this section describes the contaminated media and evaluates GRAs, technologies, and process options that are potentially viable for addressing them to meet the RAOs and ARARs discussed in Section 3.

4.1 Contaminants and Affected Media

Selenium is the primary contaminant of interest in solid media, which includes soils and overburden in ODAs. Arsenic is also a primary contaminant of interest in solid media because of potentially unacceptable risks to future seasonal ranchers due to ingestion of beef from livestock grazing at the Site. The weathered shales in the overburden material are susceptible to leaching as water from rain and snowmelt infiltrates through these materials. ODAs with minimal or no covers allow infiltration and subsequent releases of selenium and other COCs to Wells Formation groundwater. The potential sources considered are shown in Table 2-1. The RI groundwater transport modeling indicated that the principal sources of selenium and other COCs to groundwater are: Panel A Area 2 and External ODA; and Panel D and External ODA (Table 2-4).

The contaminants of interest in aqueous media, which include groundwater and surface water in springs, are selenium and arsenic. Seepage generated within ODAs is discharged as surface seeps or migrates downward to the Wells Formation aquifer or the Sage Valley alluvial groundwater system. Wells Formation groundwater is transported to the springs complex where it discharges and is transported downstream to Sage Creek and Crow Creek. Groundwater may also be extracted from wells at the Site.

The extent of groundwater with selenium concentrations above the MCL is illustrated in Figure 3-1. Because of the complex fractured flow system in the Wells Formation aquifer at the Site it is not possible to make an accurate estimate of area and volume of groundwater with selenium concentrations above the MCL. Groundwater discharges at the springs complex, where the typical flows are in the range of 14 cfs. Selenium loading from the springs results in concentrations above the aquatic water quality standard for selenium in South Fork Sage Creek springs, Sage Creek, and Crow Creek.

There are also seeps and detention basins downgradient of the ODAs with elevated arsenic concentrations that pose potential future risks to human receptors (LP-1, DP-7, DS-7, and EP-2). Selenium concentrations and flows for ODA seeps are provided in Table 4-1. Selenium concentrations in surface water in detention basins are provided in Table 4-2.

4.2 General Response Actions

GRAs describe those actions that alone, or in combination, may be applied to areas of concern. GRAs are used to organize and structure potential remedial actions and are divided into remedial technology groups consisting of specific process options. This section identifies and describes the GRAs that may satisfy the RAOs presented in Section 3.

As described above, there are two media of concern within the Site: solid and aqueous. The solid media category includes contaminated soils and overburden in ODAs (referred to as solids and soils), and any residual solid material remaining after treatment. The aqueous media category includes groundwater and surface water. GRAs and remedial technologies have not been developed for the air medium because airborne transport of contaminants is an incomplete pathway (Formation 2015a, 2015b, 2016a).

The GRAs identified for the Site are:

- No Action
- Institutional Controls
- Access Controls
- Containment
- Source Control, Flow Control and Routing
- Removal and Disposal
- Treatment
- Monitored Natural Attenuation

The remedial technologies and process options associated with these GRAs are shown in Figure 4-1. GRAs and remedial technologies are briefly described in Section 4.3. More detailed descriptions of remedial technologies and process options and the results of the initial screening process for technical implementability are provided in Section 4.4 and Figure 4-2.

4.3 Identification of Remedial Technologies and Process Options

Remedial options are generally grouped by how they minimize contaminant release, contaminant transport, or risks associated with contaminants. Source control and containment remedial options reduce the release and/or transport of selenium and other COCs from the ODAs. Removal remedial options remove and dispose of waste material, contaminated soil, and or contaminated surface water and groundwater. Treatment remedial options are applied to reduce concentrations of selenium and other COCs in impacted surface water and groundwater. Monitored natural attenuation (MNA) is a natural process that may be used in conjunction with other technologies and process options. Institutional controls limit the potential for human activities to result in exposure to impacted media (e.g., water, soil, and vegetation). Access controls may be used to prevent access to source areas. In practice, it will take a combination of remedial options from all of these groups to effectively minimize the impact and risk associated with the ODAs.

This section describes typical approaches and methods that could be used to control selenium releases from overburden and available treatment technologies for removing selenium and other COCs from impacted waters.

4.3.1 No Action

The No Action GRA is required by the NCP as a baseline for comparison; however, because early actions have been implemented at the Pole Canyon ODA, this alternative becomes No Further Action.

Two NTCRAs were implemented at the Pole Canyon ODA to divert Pole Canyon Creek stream flow around the ODA, prevent run-on to the ODA from the northern hillside slope, and reduce or eliminate infiltration into the ODA. Under the No Further Action GRA, the operations and maintenance (O&M) activities for the NTCRAs would continue as required by the Settlement Agreements (USFS, USEPA and IDEQ 2006; USFS, IDEQ, and Tribes 2013). Water treatment at the pilot treatability study at the springs complex would be terminated.

4.3.2 Institutional Controls

Institutional controls are non-engineering mechanisms that provide the means by which federal, state and local governments or private parties can prevent or limit access to or use of contaminated environmental media, the use of areas impacted by contaminants, and/or to provide for the integrity and maintenance of engineered remedial components. The NCP emphasizes that institutional controls are meant to supplement engineering controls and may be a necessary component of the selected remedy. The NCP also cautions against the use of institutional controls as the sole remedy unless active response measures are determined to be impracticable. The USEPA recognizes four types of institutional controls (1) government controls, (2) proprietary controls, (3) enforcement and permit tools, and (4) information devices (USEPA 2000, 2012). Institutional controls may be applied on a stand-alone basis or implemented in conjunction with other response actions as part of an overall remedy.

4.3.3 Access Controls

Access controls are physical barriers to limit access to source areas. Physical barriers may include fences and gates. Fences and gates are fixed structures that function as boundaries, barriers, or other means of security. Access controls may be temporary or permanent and may be implemented as separate, unconnected technologies or applied along with other remedial technologies as part of an overall remedy.

4.3.4 Containment

The containment GRA includes technologies and process options resulting in the physical containment or isolation of source areas to limit exposure and reduce the transport of selenium and other COCs. Containment technologies include (1) engineered covers, (2) barriers, and (3) sediment control features. Long-term maintenance requirements, including periodic inspection and monitoring, may be required for containment options.

4.3.5 Source Control, Flow Control and Routing

The source control GRA consists of active measures to manage sources and reduce the flow of water to source areas and subsequent release of selenium and other COCs into surrounding soils, groundwater, and surface water. Source controls include surface controls and slope stabilization. Grading, vegetation, and erosion protection are examples of source controls. Slope stabilization includes reducing slope grades and constructing retaining walls. At the Site, this GRA may be implemented alone or combined with other actions.

The flow control and routing GRA applies to surface water and consists of diversion via open channels or closed conduits. Flow control and routing has already been implemented by the 2006 NTCRA where Pole Canyon Creek flow is collected above the Pole Canyon ODA and piped to the valley below the ODA. An infiltration basin, installed just uphill from the ODA, allows any creek water from below the pipeline diversion to infiltrate before reaching the ODA. A run-on control ditch was also installed on the uphill side of the ODA. These actions prevent water from contacting ODA material and subsequently mobilizing selenium and other COCs. Other actions that have been implemented at the Site are routing and collection of ODA seeps and storm water runoff in detention ponds, and installation of ditches to convey storm water away from source materials. Additional flow control and routing actions may be implemented along with other actions.

4.3.6 Removal and Disposal

This GRA involves the removal and disposal of solid or aqueous media with concentrations of selenium or other COCs exceeding specified action levels or standards. Several technologies and process options exist within the removal GRA for remediation of overburden solids and soils and groundwater and surface water at the Site. Removal technologies include excavation of solids and collection of surface water or groundwater using extraction wells or trenches. Disposal technologies involve onsite consolidation, onsite or offsite disposal of treatment residuals and/or other solids, and onsite or offsite discharge of groundwater and/or surface water or injection. This GRA is often combined with other GRAs such as institutional controls, containment, flow control and routing, or treatment. Long-term maintenance requirements, including periodic inspection and monitoring, may be required for removal options.

4.3.7 Treatment

This section presents the ex-situ and in-situ treatment options evaluated for groundwater and surface water and for solids and soils at Smoky Canyon Mine.

4.3.7.1 Ex-Situ Treatment

Ex-situ treatment technologies are remediation options where the affected medium is removed from its original location for processing.

Groundwater and Surface Water

Physical treatment methods involve removing contaminants from water without chemically altering them. These methods typically employ processes such as separation (mechanical, gravity and media filtration), or demineralization (ion exchange, reverse osmosis, ultrafiltration, and electrodialysis). Physical treatment may be applied on a stand-alone basis or implemented in conjunction with other treatment technologies.

Chemical treatment involves processes where contaminants are altered or precipitated from solution. Most chemical treatment methods have a secondary waste stream that requires further treatment and disposal. Chemical treatment methods included for initial screening are adsorption (activated carbon and metal oxide), solvent extraction, chemical precipitation, and oxidation/reduction.

Biological reduction removes inorganic constituents by reducing oxidized forms to elemental forms, which are typically less mobile and easier to precipitate out of water. For organic constituents, microbial activities can transform organic components to intermediate products and basic constituents such as carbon dioxide and water.

Thermal treatment is the process of applying energy to the water being treated to evaporate clean water, while leaving behind contaminants in a concentrated brine. Thermal treatment methods considered include mechanical evaporation and wet air oxidation.

Solids and Soils

Physical treatment technologies reduce the mobility or toxicity of contaminants or reduce the volume by changing the physical properties of the materials (by lowering moisture content, increasing density, and/or reducing permeability). Physical treatment methods evaluated include stabilization/fixation, dewatering, and separation.

Thermal treatment technologies involve the application of energy to catalyze reactions that immobilize or detoxify inorganic compounds or destroy organic compounds by oxidation or separation by distillation or volatilization. Process options considered are incineration and desorption.

Chemical treatment promotes reactions that convert contaminants into less hazardous compounds. Chemical treatment process options included in the initial screening are oxidation/reduction, hydrolysis, and chemical extraction.

Biological treatment of solids and soils consists of enhancing the biological degradation or reduction of contaminants by microorganisms. Biological treatment, including land farming, is typically implemented by creating favorable conditions for native microbial activity.

4.3.7.2 In-Situ Treatment

In-situ treatment technologies are process options designed to remediate media in place.

Groundwater and Surface Water

In-situ chemical treatment involves injecting chemicals directly into the impacted region of the aquifer to treat the groundwater or in the impacted surface water. The injected chemical agent interacts with the constituents in the water to neutralize, precipitate, immobilize, fixate, or destroy the contaminants.

In-situ biological treatment of groundwater and surface water (e.g., through injection wells, infiltration trenches, and permeable reactive barriers) consists of enhancing the conditions in the water to reduce contaminants by microbial activity. This is typically achieved by injecting nutrients to preferentially favor the microorganisms that can degrade or reduce the target contaminants.

Solids and Soils

In-situ physical/chemical treatment technologies include stabilization/fixation and aeration. Stabilization/fixation is performed by using special machinery to directly inject stabilizing agents, such as cement, into the soil. Types of equipment and methods used to deliver the stabilization agents into soils include rotary injection augers, jet grouting, and pressure grouting. Aeration of soils is typically achieved by soil vapor extraction.

Thermal treatment technologies involve the application of thermal energy to catalyze reactions that immobilize or detoxify inorganic contaminants or destroy organic compounds by oxidation or separation by distillation or volatilization. Thermal treatments evaluated include vitrification and desorption.

In-situ biological treatment involves technologies where the solids are treated in place. Nutrients are injected into the solids and soils to encourage favorable microbial growth. Biological process options evaluated include enhanced biodegradation and phytoremediation.

4.3.8 Monitored Natural Attenuation

MNA can be used in conjunction with the above-mentioned GRAs to achieve remedial objectives for groundwater. The rationale is that natural processes can contribute to the reduction of COC concentrations in areas where releases and transport have already occurred. In groundwater, MNA can occur through physical (e.g., dilution, dispersion, sorption), geochemical (e.g., sorption, precipitation), and biochemical (biologically-mediated reduction) processes.

Selenium occurs as three principal aqueous species in oxygenated water: selenite (SeO_3^{2-}), biselenite ($HSeO_3^-$) and selenate (SeO_4^{2-}) (Hem 1989; Masscheleyn et al. 1990), and the dominant species in solution depends on water chemistry and redox conditions. Geochemical controls that reduce or limit the solubility of selenium in water include sorption to mineral surfaces such as oxyhydroxides of iron, manganese, and aluminum (Hayes et al. 1987; Balistrieri and Chao 1990; Rajan 1979). Clay and carbonate minerals may also provide effective sorption surfaces for selenium (Bar-Yosef and Meek 1987; Cowan et al. 1990). In general, selenate is less strongly sorbed to mineral surfaces than is selenite. Redox potential and pH both affect selenium solubility and sorption reactions. Sorption reactions for selenium are least efficient under oxidizing conditions at circum-neutral pH (Elrashidi et al. 1987).

The degree to which sorption attenuates groundwater transport of selenium, as well as other trace metals, depends on the aqueous speciation of selenium (or other trace metals), sorption site density, affinity of the dissolved chemical for the solid phase (Benjamin and Leckie 1981), solid-surface charge, concentrations of competing ions (e.g., sulfate, phosphate, nitrate, etc.), and ionic strength of the solution (Stumm and Morgan 1981). These factors may vary spatially and with depth in aquifer.

Selenium attenuation can also occur due to biologically-mediated reactions in environments with low oxygen (i.e., anoxic, oxygen levels below 0.5 mg/L) (Kirk 2014). Under low-oxygen conditions, microbes reduce the most mobile form of selenium in solution, selenate (SeO42-), to less mobile forms thereby limiting selenium transport via groundwater flow. The ratio of selenium to sulfate is also a useful method for evaluating the occurrence of attenuation (Hay et al. 2016).

4.4 Screening of Remedial Technologies and Process Options for Technical Implementability

The remedial technologies and process options identified in Figure 4-1 and described in Section 4.3 were screened based on technical implementability. A wide range of potential remedial technologies and process options were reviewed to evaluate the suitability for addressing residual overburden materials and impacted groundwater and surface water. A given technology or process option was eliminated from further consideration on the basis of technical implementability if site conditions or site characterization data indicated that the technology or process option is incompatible with the COCs or cannot be implemented effectively because of physical limits or constraints. A summary of the initial screening of remedial technologies and associated process options in terms of technical implementability is presented in Figure 4-2. Process options eliminated from further evaluation are shaded gray.

4.4.1 No Action

The No Action GRA is required by the NCP as a baseline for comparison and is therefore retained for further evaluation. The No Action GRA is not divided into technologies and process options. Because previous work has occurred at Smoky Canyon, this alternative becomes a No Further Action alternative. NTCRAs that have already been implemented would continue. Pilot treatability studies would be terminated.

4.4.2 Institutional Controls

Institutional controls are administrative and legal mechanisms that help to minimize the potential for exposure to contamination and/or protect the integrity of a response action. They may be used alone or in conjunction with other alternatives as part of an overall remedy. Institutional controls are meant to supplement engineering controls during all phases of cleanup and may be a necessary component of the selected remedy.

Four types of institutional controls are evaluated (1) government controls, (2) proprietary controls, (3) enforcement and permit tools, and (4) information devices.

Government controls are usually implemented and enforced by a federal, state, or local government or government agency and may include zoning restrictions, land-use controls, forest closure orders, grazing controls, ordinances, building permits, or other provisions that restrict land or resource use. Forest closure orders could be used to prevent access to areas on National Forest System land. Government controls such as zoning restrictions and forest closure orders that restrict land use or prevent access are potentially implementable and are retained for further evaluation. Controlling domestic livestock grazing would allow establishment of vegetation on recently seeded areas and is retained for further consideration.

Proprietary controls are property-use restrictions based on private property law and may include deed restrictions, easements, or covenants. Deed restrictions are rules and regulations that govern one or more parcels of land. They are recorded with the county and are permanent and “run with the land,” so they bind all current and future owners of the parcel(s). In the case of land owned by Simplot, these proprietary controls may be used to prevent future use of alluvial or Wells Formation groundwater with arsenic or selenium concentrations above MCLs as a drinking water source. Deed restrictions are viable for use at the Site and are retained for further evaluation.

Enforcement and permit tools are legal tools such as administrative orders, federal facility agreements, and consent decrees that limit certain activities or require the performance of specific activities such as monitoring or reporting on effectiveness. These legal tools may be issued unilaterally or negotiated and are legally binding and could be enforced. Enforcement and permit tools are viable for use at the Site and are retained for further evaluation.

Information devices provide information or notification that residual or covered contamination may remain at a site. Such tools take a variety of forms and may include signs, deed notices, public information programs, and state registries of contaminated sites. Signs convey information on land use or land-use restrictions; materials used to produce the sign must last for the length of time that the warning will be posted. The Forest Service has posted a notification/warning sign on Smoky Canyon Mine Road. In the future, the Forest Service may elect to post warnings signs to inform the public about the overburden material buried at the Site. Although information devices as an institutional control are not enforceable, signs, and public information programs and are potentially implementable for use at the Site and are retained for further evaluation.

4.4.3 Access Controls

Access controls are physical barriers such as fences and gates to limit access to source areas at a site (e.g., ODAs or seeps or springs). Fences and gates are fixed structures that function as boundaries, barriers, or other means of security. Fencing off a reclaimed/revegetated area can limit the uptake of selenium and other COCs by wildlife and prevent damage to the area while vegetation is becoming established. By fencing off areas with vegetation high in selenium and other COCs or water sources high in selenium and other COCs, the impact to wildlife could be reduced. The type of fence can vary from a three-strand barbed wire to a game-exclusion fence depending on the objective of implementing this access control. However, fences/gates should not be thought of as stand-alone controls, rather they should be implemented in conjunction with source controls. Fences and gates must be adequately maintained. Portions of the Pole Canyon ODA were fenced prior to construction of the NTCRA. Physical barriers such as fences and gates are potentially implementable and are retained for further evaluation.

4.4.4 Containment

Several technologies and process options within the containment GRA are identified and considered for solid media and groundwater and surface water that exceed standards or action levels. This GRA consists of containment measures to prevent or limit exposure to impacted media rather than treatment of the media. Some of the technologies are applicable to both solid and aqueous media water while others are applicable specifically to either solids and soils or groundwater and surface water. These technologies and process options could be used alone or in conjunction with surface control and flow control and routing technologies and process options.

4.4.4.1 Engineered Covers

Engineered covers are commonly used to prevent direct contact with seleniferous materials and to reduce infiltration and erosion, thereby reducing the release of selenium and arsenic that may potentially impact groundwater and surface water. Covers have already been used extensively at the Site for post-mining reclamation. Engineered covers are therefore applicable to overburden solids and soils but may also provide benefits for groundwater and surface water. There are a variety of available engineered cover designs.

Various cover types, as well as encapsulation of seleniferous material, are discussed in the Selenium Management Practices document (Interagency/Phosphate Industry Selenium Working Group [SeWG] 2005). General design requirements for engineered covers include impedance of liquid migration through the solid media, maintenance requirements, sufficient drainage, resistance to damage by animal activity, settling, or subsidence, with a permeability lower than or equal to the underlying natural soils. Simplot identified source areas and available volumes of the primary material types to be evaluated for use in CERCLA cover systems (i.e., soil, tailings, Rex Chert and limestone gravel, and Dinwoody Formation material) that are considered for the FS (Formation 2016b). These cover systems are described below.

<u>Soil Cover</u>

A soil cover can provide a physical barrier between the vegetation root zone and ODA materials, thus reducing the potential for selenium uptake by selenium-accumulating plants along with preventing direct contact and ingestion by potential receptors. Of particular interest in semi-arid environments is the use of a cover designed to store rainwater and release it via evapotranspiration through the vegetative cover. It can also reduce infiltration of precipitation into the underlying overburden materials. The soil cover is potentially implementable and is retained for further evaluation.

<u>Tailings Cover</u>

As described in the Cover System Pilot Study Memorandum (Formation 2014b), Site-specific physical and chemical data for tailings indicate that tailings material is likely to be suitable for use in ODA covers. Two tailings impoundments, Tailings Pond 1 (TP1) and Tailings Pond 2 (TP2) are adjacent to the Site. Several million cubic yards of tailings are available in the impoundments and approximately 500,000 dry tons are generated each year by ongoing mining operations. Tailings material can provide a physical barrier between the vegetation root zone and ODA materials, thus reducing the potential for selenium uptake by selenium-accumulating plants along with preventing direct contact and ingestion by potential receptors.

The physical properties of Smoky Canyon tailings were evaluated in recent geotechnical testing as part of the Dairy Syncline planning process (Golder 2013). Based on the results, a minimum saturated hydraulic conductivity of 10^{-5} centimeters per second (cm/s) was estimated. This is in the range of hydraulic conductivity of Dinwoody Formation material measured at the Site. The Tailings Revegetation Field-Scale Pilot Study was a 5-year study that was performed near the Smoky Canyon tailings impoundments (Formation 2013c) and investigated plant uptake of selenium and the performance of tailings as a growth medium. This study found that seeded vegetation can establish and grow on tailings material, with or without amendments, and selenium uptake into plants is low. The results show that uptake of selenium by plants growing on tailings would not be an ecological risk issue. Tailings material is potentially implementable for use as a single-layer cover and as a component of a multi-layer cover system and is retained for further evaluation.

Chert/Limestone Cover

Chert and/or limestone layers are used as physical barriers in cover systems. When installed directly above the ROM overburden, chert/limestone provides a capillary break, or an additional thickness of non-seleniferous overburden within the cover profile to prevent vegetation from rooting in overburden materials higher in selenium and other COCs (i.e. center waste shale), and to prevent vegetative uptake and potential risk to foraging animals. Additionally, the coarse texture and corresponding low water-holding capacity result in unfavorable conditions for root advancement through the chert/limestone and into the overburden. Chert may also help prevent small mammals from burrowing into the overburden material. A capillary break layer can provide lateral drainage, which can improve the long-term stability of the cover. Chert and limestone from the Rex Chert Member of the Phosphoria Formation are available from ongoing mining operations and have a generally coarse composition dominated by gravels with some sands and few fines.

Potential use of chert/limestone for cover material was evaluated as part of the EE/CA process for the Pole Canyon NTCRA (Formation 2012a). Due to the coarse textural composition, chert/limestone is unfavorable as a growth medium (i.e., would not support vegetation growth) without additional amendments; if used alone as a surface cover material, chert/limestone would actually result in increased infiltration compared with the existing overburden due to its high saturated hydraulic conductivity. Therefore, use of chert/limestone was considered only as a layer between the growth medium and ROM overburden or as a water conveyance layer in a more complex cover system (i.e. geosynthetic clay liner [GCL], Dinwoody Formation material, or tailings). In this position in the cover system, the thickness of the chert/limestone cover does little to influence the amount of net percolation into the underlying overburden. Therefore, the thickness of chert/limestone should be determined based on its function as a barrier or its water conveyance performance. The rate of generation and availability of chert and/or limestone from active mining operations is a key factor in the scope and timing of implementation. The chert/limestone cover is potentially implementable, is a proven, effective material, and is retained for further evaluation.

Dinwoody Cover

Dinwoody Formation material is well suited for use in cover systems at the Site. It is a locally available material that could be accessed in areas near the ODAs. Although there is some variability in the composition and material properties of the Dinwoody Formation at the Site, it is generally comprised of interbedded siltstone, shale, and limestone that grade into a calcareous shale and siltstone with depth. Typically, Dinwoody is a poorly-graded, fine-textured material with a low saturated hydraulic conductivity and a high moisture storage capacity. The gradation and texture of Dinwoody provide a growth medium that supports vegetation, and the low saturated hydraulic conductivity of the Dinwoody reduces net infiltration.

The effectiveness of using Dinwoody material for cover systems has been demonstrated on Panel E (Formation 2012a), where it has provided stable reclamation surfaces and resulted in successful growth of vegetation. Dinwoody material was also used as part of the cover system for the 2013 NTCRA on the Pole Canyon ODA. The NTCRA included minor grading of the ODA, placement of a 2-foot-thick chert/limestone cover overlain by a 3-foot-thick Dinwoody cover, installation of storm water runoff controls, and revegetation with non-selenium-accumulating species. A variety of configurations are possible, including a water balance cover (typically a monolithic design constructed of 4 to 10 feet of fine-textured soil [e.g., sandy silt] and vegetated with local grasses) (Albright et al., 2004, 2009). The Dinwoody cover is potentially implementable, is a proven, effective material, and is retained as a cover option.

Geosynthetic Covers

Geosynthetic covers consist of multiple layers and may include a geomembrane (GM) or a GCL. A GCL is a woven fabric-like material that incorporates a bentonite or other clay, which has a very low hydraulic conductivity. A geosynthetic clay laminate liner (GCLL) includes a layer of bentonite clay inserted between two geotextile layers. The top geotextile layer is laminated with a polyethylene geomembrane layer, providing an additional layer of protection against desiccation and ion exchange degradation. If a low permeability cover such as a GM or GCL is used, an overlying natural or geosynthetic drainage layer must be placed just below the soil or rock cover and the closure slope generally needs to be flatter than 3:1 to achieve stability of the cover over the geosynthetic materials. If a GM is selected, it must have high internal shear strength to provide stability on side slopes steeper than 5:1. For side slopes of 3:1, additional anchoring of the geosynthetic is required and angular gravel or rock is required above a geotextile for stability of this layer. The use of a geosynthetic cover is potentially implementable and is retained as a possible cover technology.

4.4.4.2 Barriers

Vertical barriers may be used to control migration of contaminants in groundwater. Low permeability cutoff walls or diversions may be installed below ground to contain, capture, or redirect groundwater flow.

Slurry Walls

Slurry walls are the most common subsurface barriers because they use conventional technology and are an effective means of reducing groundwater flow in unconsolidated earth materials. A slurry wall is constructed by blending a soil mixture with a bentonite slurry and placing the mixture in a vertical trench to form a low permeability barrier wall. In some cases, the trench is excavated under a slurry of cement, bentonite, and water, and this mixture is left in the trench to harden. Slurry walls are not feasible at the Site due to the number of sources and depth of the Wells Formation aquifer and the extent of slurry walls that would be required to control groundwater flow. Slurry walls are not implementable and therefore are not retained.

Sheet Piling

Sheet piling may be used to form a physical groundwater barrier. Sheet piles are made of wood, synthetic materials, pre-cast concrete or steel. Concrete is used primarily where great strength is required. Steel is often the most effective form of sheet pile cutoff. However, interlocks between barrier panels may be difficult to seal. Sheet piling is not feasible at the Site due to the number of sources and the depth of the Wells Formation aquifer and the extent of sheet piling that would be necessary to control groundwater flow. Sheet piling is not implementable and is not retained.

Rock Grouting

Rock grouting or grout curtains are subsurface barriers created in fractured or unconsolidated materials by pressure injection of a low permeability grout mixture. The vibrating beam method, where grout is placed in the void left from the retreat of a previously driven pile, is most often used to place grout to generate a wall in unconsolidated soils. Pressure injection of grout and grout placement using the vibrating beam method are not feasible because of the extent required to control groundwater and the depth of the Wells Formation aquifer. Rock grouting is not implementable and is not retained.

4.4.4.3 Sediment Control Features

Sediment control features may be used to reduce or eliminate loading of sediment in a stream or to minimize the movement of sediments already in the channel. Process options for the sediment control remedial technology include dikes or berms and detention basins. Within the Site, such sediment controls are applicable only to storm water runoff and would not be appropriate for use in various drainages where containment process options (e.g., rock covers) would be more effective in terms of controlling sediment mobilization.

Dikes/Berms

Dikes and berms consist of grading and reshaping the surface of the land in order to manage surface water infiltration and runoff while controlling erosion. Dikes and berms must be blended with surrounding undisturbed ground to provide a smooth transition in topography. Dikes and berms have been implemented at the Site and are potentially implementable for future actions and are retained for further evaluation.

Detention Basins

Detention basins, also termed sedimentation basins or ponds, detain storm water runoff allowing sediments to settle out of the water. Detention basins have been shown to be moderately to highly effective in settling and removing sediment and moderately effective at minimizing contaminant volume. Detention basins have been applied as BMPs at several of the external ODAs at the Site. Detention basins are implementable and are retained for further evaluation.

4.4.5 Source Control, Flow Control and Routing

Source control, flow control and routing GRAs consist of active measures to effectively manage source materials (e.g., overburden solids and soils) and groundwater and surface water contact (flow volume, velocity, and direction) with those source materials. In particular, these technologies limit the transport of COCs to surface water. Source control, flow control and routing may be used as stand-alone technologies or in conjunction with other technologies.

4.4.5.1 Surface Controls

Surface control process options considered for use at the Site include grading, erosion control and protection, and vegetation. These process options are applicable to overburden solids and soils but may also provide benefits for groundwater and surface water by reducing/eliminating releases of selenium from overburden into groundwater or surface water. Any land surface alterations associated with surface controls must be blended with surrounding undisturbed ground to provide a smooth transition in topography.

Grading

Grading is the general term for techniques used to reshape the surface of the land in order to manage surface water infiltration and runoff while controlling erosion, thereby providing both source control for overburden solids and soils and flow control for groundwater and surface water. The general equipment and methods used in grading are conventional technologies, readily available and essentially the same for all surfaces. However, specific applications of grading technology will vary by site. Grading is often conducted in conjunction with surface preparation practices and revegetation as part of an integrated site remediation, which includes other actions such as containment. Grading is implementable and is retained for use in conjunction with other technologies.

Erosion Control and Protection

Erosion protection consists of the use of erosion-resistant materials such as riprap, vegetation, and geosynthetic fabrics to reduce or eliminate erosion of solid media by storm water runoff. These materials are often installed after regrading of the surface has been performed. Erosion protection uses conventional equipment and materials. Erosion-control fabrics can promote vegetation by retaining moisture and protecting the seedlings during germination. Maintenance requirements for these erosion protection measures are minimal. Erosion protection is suitable for dry mine waste (i.e., overburden), impacted surface soils, and impacted subsurface soils above the water table. This process option could be used with other technologies or as a stand-alone technology. Erosion control protection is implementable and is retained for further evaluation.

Vegetation

Establishing a vegetative cover is a standard surface reclamation technology for ODAs. In addition to stabilizing surface materials by reducing erosion potential, the vegetation increases evapotranspiration at the surface and reduces water infiltration into overburden and subsequent release of selenium and other COCs. The 2006 Smoky Canyon Mine EE/CA (NewFields 2006a) suggested that infiltration may be decreased by as much as 50% by establishing a well-vegetated cover on poorly vegetated overburden. Although this 50% reduction was not determined from modeling, it was applied to several alternatives to roughly estimate the potential benefits of establishing a good vegetative cover. Planting of native species that have low affinity for selenium uptake may be effective in reducing potential risks to ecological receptors. Vegetation also improves aesthetics. Previous response actions at the Pole Canyon ODA have demonstrated the effectiveness and implementability of revegetation measures in conjunction with containment/covers (NewFields 2006a; Formation 2012a). Vegetation is implementable and is retained for further evaluation in conjunction with engineered cover process options.

4.4.5.2 Slope Stabilization

Slope stabilization technology includes slope reduction and retaining walls to reduce erosion and sediment transport. Slope stabilization process options are often used in combination with other technologies or process options in containment and flow control and routing GRAs. Slope stabilization is applicable to overburden solids and soils.

Slope Reduction

Slope reduction consists of flattening or reducing the grade of the surface slopes of areas of concern including ODAs. This slows storm water runoff velocity, limits erosion, promotes vegetation, and reduces the potential for slope failure. Slope reduction is implementable and is retained for further evaluation.

Retaining Walls

Retaining walls may be used with grading/slope reduction to stabilize steep soil slopes by reducing the effective slope of an earthen surface. Retaining walls are rigid vertical or near vertical structures of steel beams and sheets, concrete, masonry blocks, wood, rock, or other materials capable of withstanding the structural forces imparted by the soil on the uphill face of the wall. This process option is constructed using conventional techniques. Retaining walls are potentially implementable and are retained for further evaluation for use in ODA cover construction if needed to stabilize slopes.

4.4.5.3 Diversion

Diversion consists of routing or managing flow within open channels or closed conduits, and is applicable to surface water, specifically storm water. Flows could be diverted to open surface water bodies, sedimentation basins, or treatment systems.

Diversion ditches could be used to prevent “clean” surface water from contacting the overburden in a disposal area. Additionally, diversion ditches could be constructed on an ODA to manage runoff in such a manner as to limit infiltration and resultant leaching. This remedial technology limits the release of selenium and other COCs from overburden and migration from the ODA to nearby surface water or groundwater. Diversion ditches are effective if they are adequately designed and maintained. At the Site, diversion ditches would be effective upgradient of certain ODAs to reduce clean surface water run-on from the adjacent slopes by diverting it into existing creeks. They may also be used on long ODA slopes to shuttle water off the overburden.

Stream alterations could be used to limit the “clean” water that comes in contact with overburden. This is accomplished by diverting the natural stream channel away from an ODA or backfilled pit using closed conduits (e.g., culverts and piping), infiltration basins, and/or construction of a new stream channel that mimics the natural stream features in the area. Permits must typically be obtained from both the Idaho Department of Water Resources and the Army Corps of Engineers prior to implementation. Although under CERCLA the need for such permits is waived, the substantive requirements must still be met. Stream alterations are effective if they are adequately designed and maintained. Stream alteration was used as a component of the NTCRA for the Pole Canyon ODA.

Open Channels

Open channels are engineered canals or ditches constructed for the purpose of collecting and conveying surface water. Constructed conventionally by excavating and shaping the ground surface, open channels are usually lined with vegetation, riprap, or concrete, as necessary and appropriate for the anticipated flows, channel dimensions and gradient, to prevent erosion by surface water. These channels are constructed with engineered grades and side slopes for specifically designed flow volumes and velocities and may also be used to manage groundwater flow after collection. Open channels are potentially implementable and are retained for further evaluation.

Closed Conduits

Closed conduits also provide a means to manage and control surface water. Closed conduits usually consist of culverts or pipes and are typically constructed of high-density polyethylene plastic, polyvinyl chloride plastic, corrugated metal, steel, or concrete depending on the engineering requirements. Often used for conveying flow on steeper grades, where space is limited, or infrastructure encroaches, closed conduits minimize or eliminate erosion of surface soils. Closed conduits must be maintained to ensure proper operation. Similar to open channels, closed conduits can also be used to route groundwater flow after collection. Closed conduits are potentially implementable and are retained as a process option for further evaluation.

4.4.6 Removal and Disposal

Remedial technologies for the removal and disposal GRA for overburden solids and soils and groundwater include excavation of solids and soils, collection of groundwater using extraction wells or trenches, and disposal or consolidation either onsite or offsite.

4.4.6.1 Excavation

Excavation involves physical removal and transport of solid materials from one location to another. This technology could be combined with technologies or process options from other GRAs such as containment, treatment, or disposal. Conventional excavation involves the use of earthmoving equipment (backhoes, trackhoes, scrapers, front-end loaders, and/or bulldozers) to dig, scrape or push materials that require treatment, relocation, or contouring. Conventional excavation could be used for removal of overburden solids or waste rock materials and soils and sediments from ODAs or detention basins, or for contouring an area prior to construction of a cover system. The removed materials would be further treated, consolidated, placed under a cap or used in the construction of a cover system. Excavation could be easily implemented for excavation and consolidation of solid materials (waste rock) or excavation and reuse of soils as part of the remedial action and is retained as a process option for further evaluation.

4.4.6.2 Collection

Process options for collection of groundwater include extraction wells and interception trenches. Once collected, the groundwater may be either treated or disposed.

<u>Extraction Wells</u>

Extraction wells can typically be used to capture groundwater and control gradients and flow direction. Wells are constructed with conventional drilling equipment and materials. Extraction wells create a local groundwater sink that causes flow toward the well. Once extracted, the groundwater could be routed and managed as necessary. Multiple extraction wells could be installed along preferential pathways and along the West Sage Valley Branch Fault. Extracted groundwater could be treated and discharged or reintroduced.

The RI, however, demonstrated that groundwater flow within the Wells Formation is influenced by preferential flow paths. In fact, placement of a Wells Formation well within zones of high transmissivity and high concentrations of COCs is difficult. Monitoring wells GW-18 and GW-24 are examples. These Wells Formation monitoring wells were placed near the West Sage Valley Branch Fault and downgradient of the Pole Canyon ODA and Panel E, respectively. The Wells Formation at GW-24 is low transmissivity while GW-18 is in a high transmissivity zone. Concentrations of selenium in groundwater samples collected from GW-18 and GW-24 are below the MCL for selenium. Moreover, GW-18 is located less than 700 feet upgradient of Hoopes Spring where the maximum observed selenium concentration is approximately 10 times higher than concentrations observed at GW-18. The presence of preferential flow paths was further demonstrated by the range of observed selenium concentrations from discrete springs sampled at Hoopes Spring during the RI.

In short, use of extraction wells upgradient of Hoopes Spring is unlikely to be effective due to known hydrogeologic complexities. Moreover, Hoopes Spring acts as a regional groundwater discharge feature, which effectively captures the migration of COCs within Wells Formation groundwater in the southern groundwater flow system.

Extraction using pumping wells, similar to the previous Culinary Well and the Industrial Well, could be implemented and is retained as a process option for further evaluation.

Trenches

Interception trenches are excavated ditches or channels used to collect, control, and manage groundwater flow. The trenches are excavated to a depth greater than the groundwater table and are either maintained as open trenches or filled with permeable material such as riprap, drain rock, or drainage pipe. Groundwater flows toward and is intercepted by the trench. The trench could be designed to control the level of the water in the vicinity of the trench. Once in the trench, the water may be managed and routed as necessary. Both closed (gravel-filled or pipe) or open trenches are effective for collection of groundwater in low permeability soils with shallow groundwater tables. Due to the complex geology at the Site, deep Wells Formation groundwater that has been impacted by releases from ODAs flows along preferential pathways and along the West Sage Valley Branch Fault and discharges at Hoopes Spring and South Fork Sage Creek springs. Because most of the groundwater at the Site is in the deep Wells Formation aquifer, collection trenches are not implementable and are not retained as a process option for groundwater collection.

4.4.6.3 Solids Disposal

Disposal process options available for solid media include onsite consolidation/onsite disposal or offsite disposal at a disposal facility.

Onsite Consolidation/Onsite Disposal

Consolidating overburden can limit the water in flow, the oxygen in flux, and the uptake by vegetation thus limiting the impact to surface water, groundwater, and wildlife. By consolidating material into one disposal area, there could be an overall reduction in surface area available for infiltration of precipitation and leaching of contaminants, while also providing an environment within the disposal area that is more conducive to lower oxidation rates. Onsite consolidation of small volumes of nonhazardous treatment residuals from treatment systems (e.g., sludge from a fluidized bed bioreactor system or spent media from a passive treatment system) in backfilled pits could minimize leaching of selenium and other COCs from external ODAs. Onsite consolidation of larger volumes of overburden material by backfilling pits and reclaiming slopes would be beneficial to reduce the overall footprint of waste materials. Onsite consolidation/onsite disposal is potentially implementable, as long as the disposal setting is suitable to prevent remobilization of COCs into the environment and is retained for further evaluation.

Offsite Disposal

Excavated solid media may be disposed of offsite. Offsite disposal requires excavating the impacted solid media and transporting the media to an appropriate disposal facility. Although not generally required for mine wastes, pretreatment of mine wastes that exceed Resource

Conservation and Recovery Act (RCRA) toxicity criteria, based on the toxicity characteristic leaching procedure (TCLP) test (EPA Method 1311) would be required prior to disposal in a hazardous waste landfill. Offsite disposal would reduce the volume of waste material and is considered to be a suitable process option for all solid media. Offsite disposal is potentially implementable and is retained for further evaluation.

4.4.6.4 Groundwater/Surface Water Disposal

Disposal options for groundwater or surface water include injection or conveyance and discharge to an appropriate treatment or other storage/disposal facility.

Injection

Injection wells may be used for disposal of treated groundwater or surface water by injecting water into wells drilled into the subsurface. Groundwater at the Site occurs in alluvium and in Wells Formation bedrock. Because the valley-fill alluvial groundwater flow system discharges to surface water in Sage Creek, injection of groundwater into this system would not result in disposal and would not be feasible. Similarly, because the Wells Formation aquifer discharges at the springs complex, injected groundwater would be transported to this area, and therefore, would not be disposed. Injection of groundwater would not be feasible. Neither of these hydrogeologic units provides an appropriate situation where large quantities of water could be injected for disposal. Aqueous injection is therefore not retained for further evaluation.

Discharge to Treatment or Other Storage/Disposal Facility

Impacted groundwater or surface water may also be transported to a publicly owned treatment works or a dedicated treatment or other storage/disposal facility at the Site. There are no publicly owned treatment works in the vicinity of the Site, therefore, this option is not implementable and is not retained. Discharge to an onsite treatment or other storage/disposal facility is potentially implementable in conjunction with treatment technologies and is retained for further evaluation.

4.4.7 Treatment

4.4.7.1 Ex-Situ Treatment

This section provides more detailed information about the ex-situ treatment options evaluated, along with a preliminary screening of each technology.

<u>Groundwater and Surface Water</u>

Separation

Gravity – Gravity separation involves settling of suspended solids in ponds, basins, or tanks, with or without aid of baffles or other devices. Gravity settling typically results in sludge with a solids content of 30% to 40% by weight. The technology would not remove dissolved selenium and is not considered as a viable stand-alone treatment. However, gravity separation is potentially implementable in conjunction with other technologies that generate suspended solids and is retained for further evaluation.

Mechanical – Mechanical separation is a process to remove solids from liquids. Mechanical separation is achieved using devices such as belt presses, filter presses, and vacuum filtration units. These devices can attain up to about 70% solids concentration depending on the nature of the solids to be removed. Mechanical separation would not address the dissolved selenium in water at the Site but would potentially be implementable for dewatering waste streams from other treatment technologies and is retained for further evaluation.

Media Filtration – Media filtration is a separation process that uses granular material (typically anthracite coal and/or sand) through which influent water flows. Suspended solids are trapped on top and within the filter bed, while effluent is collected in an underdrain. As suspended particles collect in the filter media, they block the drain pores, reducing the filter effectiveness. The collected solids are rinsed out periodically by reversing the direction of the flow through the media (backwashing). Like the other physical separation processes, media filtration would not be an effective stand-alone process, but is potentially implementable and is retained for consideration in conjunction with other technologies.

Demineralization

Reverse Osmosis – Reverse osmosis is a physical treatment process in which pressurized water passes through a semipermeable membrane. The applied pressure to the waste stream is greater than the osmotic pressure of the feed water. As water passes through the membrane, dissolved constituents in the water are concentrated on the feed side of the membrane to form the waste brine and a dilute product water on the permeate side of the membrane. The waste brine may be as much as 15% to 25% of the total feed water flow and requires further handling and treatment. A treatability pilot study was conducted at Smoky Canyon Mine to evaluate the effectiveness of reverse osmosis to remove dissolved selenium and other constituents from Site waters (Formation 2011f). The selenium concentration in the influent water for the pilot study was 0.03 to 0.05 mg/L.

Selenium in the "concentrate," produced by the reverse osmosis unit, ranged from 0.14 to 0.20 mg/L. Selenium concentration in the "permeate" (effluent) from the reverse osmosis unit was effectively non-detect. The unit was capable of treating approximately 25 gallons per minute (gpm), with the concentrate comprising 5 gpm and the clean permeate the remaining 20 gpm. The results of the study showed the system was highly effective at separating and concentrating the selenium. Reverse osmosis is considered a potentially implementable technology which would need to be combined with a technology that removes selenium from the aqueous concentrate stream and is retained for further evaluation.

Ultrafiltration – Ultrafiltration is a membrane-filtration technology similar to reverse osmosis; however, the pore size in the membrane is slightly larger than the pore size in the reverse osmosis membrane allowing monovalent ions (e.g., sodium, chloride, etc.) to pass through while rejecting multivalent ions (e.g., selenium, calcium, sulfate, etc.). The proportion of water that could be treated by ultrafiltration will vary depending on its chemical composition. Ultrafiltration is considered a potentially implementable treatment technology in conjunction with or as a substitute for reverse osmosis and is retained for further consideration.

Ion Exchange – Ion exchange is a treatment method in which cation or anion exchange resins are used to remove ions from water or wastewater. Ions held by electrostatic forces to charged function groups on the surface of the ion exchange resin are replaced by ions of similar charge in the water. Ion exchange resins are selected to preferentially remove specific ions from the feed water and replace them with highly soluble, nontoxic ions. Due to regeneration and rinsing requirements, the ion exchange process would result in waste materials that would require further handling and treatment. Ion exchange is potentially implementable for selenium removal in conjunction with other processes and is retained for further evaluation.

Electrodialysis – Electrodialysis is a membrane process that employs an electric field as the driving force for separating a liquid influent into a concentrated stream and a depleted ("clean") stream. Cation exchange membranes permit only negatively charged ions to pass, while anion exchange membranes permit only positively charged ions to pass. Electrodialysis is typically used for low-flow-rate and high contaminant concentration wastewater treatment applications. While electrodialysis is effective in removing organic contaminants, it is not implementable for the removal of inorganic contaminants; therefore, it is not considered an appropriate treatment technology option and is not retained.

Adsorption

Activated Carbon – Carbon adsorption is a proven technology for the removal of organic constituents in water treatment systems. In the carbon adsorption process, water is contacted with the activated carbon in a series of packed bed columns. Although carbon adsorption is an effective method of removing organic constituents, it is only moderately effective for removal of inorganic constituents. Overall performance typically is related to water chemistry. While carbon adsorption may not be a stand-alone technology for selenium removal, the process is potentially implementable in conjunction with other technologies and is retained for further consideration.

Metal Oxide – Metal oxides such as zero-valent iron or activated alumina are capable of selective metal adsorption. As water flows through a bed of these materials, metal/metalloid ions (e.g., arsenic) are adsorbed by the surface of the iron or alumina particles in the bed. The process is pH dependent and results in a solid residue that may require further treatment and disposal. While metal oxide adsorption may not be a stand-alone technology, the process is potentially implementable in conjunction with other technologies and is retained for further consideration.

Chemical

Solvent Extraction – Solvent extraction is the separation of constituents from a liquid by contact with another, immiscible, liquid. Solvent extraction is effective on organic constituents but is not an effective treatment method for selenium or other inorganic constituents. Therefore, solvent extraction is not technically implementable and is eliminated from further screening.

Chemical Precipitation – Chemical precipitation is a treatment method in which dissolved ions/salts are precipitated in the form of insoluble salts. Precipitation is caused by addition of chemicals to reach chemical saturation and/or vary the pH. The insoluble salts may be removed from the water by sedimentation, coagulation, and/or flocculation. Precipitation is considered potentially implementable for removal of selenium in conjunction with other treatment technologies and is retained for further evaluation.

Oxidation/Reduction – Chemical oxidation and reduction use agents such as oxidation, chlorination, hydrogen peroxide, and ultraviolet light to react with contaminants and oxidize them. Oxidizing agents are non-specific and will react with any reducing agents present in the water to be treated. In some cases, the reaction products have the potential to be more toxic than the original contaminants. Care must be taken when selecting the oxidizing agents to be used. Oxidation/reduction reactions have been demonstrated as an effective stand-alone process for treatment of organics and some inorganic compounds such as cyanides. Oxidation/reduction may improve the separation characteristics for removal of selenium if used in conjunction with other treatment technologies and is retained for further evaluation.

Biological

Biodegradation – Biological treatment involves the degradation or reduction of contaminants by microorganisms. Groundwater or surface water could be extracted or pumped to a process location (e.g., wetlands, anaerobic bioreactor, or fluidized bed bioreactor) for treatment. Metals and other inorganic contaminants could be removed from the water using anaerobic bacteria that decrease the solubility via biological processes and then precipitated or absorbed by the media in the wetlands or bioreactor.

Two pilot scale biological treatment systems have been evaluated at the Site. The first system was a semi-passive, buried, anaerobic, bioreactor used to treat a low flow, high concentration seep (DS-7), which discharges to the surface at the eastern toe of the Panel D external ODA. Overburden material comprising this ODA was placed directly overlying a small stream channel during mining of Panel D (Formation 2014c). The ODA was covered with a partial topsoil and vegetative cover system in 2002. Seep DS-7 is likely the surface expression of water that infiltrates through the ODA, reaches the lower permeability material present at the ground surface beneath the ODA, and flows along the small channel. The seep is captured by detention basin DP-7 where the water either evaporates or infiltrates downward into underlying Wells Formation bedrock. The initial bioreactor vessel was amended with cheese whey, compost, and zero-valent iron to establish and maintain the appropriate environmental conditions for the targeted microorganisms. The pilot system operated for approximately 7 months and achieved a selenium removal efficiency between 72% and 97% (Moller 2002).

This pilot unit was refitted and used for about 2 years, from July 2013 to November 2015, for a semi-passive treatment pilot study. Overall, the treatment system achieved 56% removal of total selenium in seep water (Formation 2016c). The semi-passive biological treatment system is relatively easy to implement and could be installed, operated, and maintained using common materials and local feed source(s), but may need additional supplements to promote bacterial activity. Access to the pilot treatment system to adjust operational parameters to maintain treatment operation was difficult and potentially unsafe during the winter months because of the steep, snow-covered unimproved road leading to the seep and treatment system. Although the pilot treatment system was supposed to be semi-passive and required little or no maintenance, the system was more difficult to operate during the winter due to freezing within the bioreactors and required significant maintenance during spring restart. Although this semi-passive system has moderate effectiveness for removing selenium and is difficult to implement in remote locations during the wintertime, it is retained for further evaluation.

The second biological treatment pilot study is a larger scale, active water treatment plant located between Hoopes Spring and South Fork Sage Creek springs. The plant consists of an anaerobic fluidized bed bioreactor which contains media that hosts a film of bacteria that specifically target selenium for their biological metabolism. Start-up and troubleshooting for the first phase of the pilot study began in late 2014 and the system treated 200 gpm to 250 gpm of comingled flow from Hoopes Spring and South Fork Sage Creek Springs through early 2016 (Formation 2014d, 2017). The Phase 1 pilot study system operated from March 2016 to March 2017. An ultrafiltration/reverse osmosis system and a second fluidized bed bioreactor unit was added for Phase 2 in order to treat flows of 1,000 gpm to 2,000 gpm (Formation 2017). The Phase 2 pilot study system began operation in February 2018 and is ongoing. Initial data indicate that the active fluidized bed bioreactor is capable of achieving 80% to 90% removal.

Biological treatment of water at the Site is potentially implementable for removing selenium and other COCs from groundwater and surface water and is retained for further consideration.

Thermal

Mechanical Evaporation – Mechanical evaporation is a process in which water is heated to the boiling point. The water vapor is condensed to form condensate (distilled water), which is the product. The contaminants are concentrated in the water brine byproduct. Because of the large water flow rates at the Site, mechanical evaporation would not be implementable and is not retained for further consideration.

Wet Air Oxidation – Wet air oxidation is a combustion process that occurs in the liquid phase, by adding air at high pressure and elevated temperatures. The products of the reaction are water, nitrogen compounds, carbon dioxide, and an oxidized liquid stream. While the process is appropriate for destroying organic compounds, it is not implementable for inorganics; therefore, wet air oxidation is not a viable process option for the Site and is not retained.

<u>Solids and Soils</u>

Physical

Stabilization/Fixation – Stabilization/fixation is a technology in which inorganic or organic agents are added to impacted soil to reduce the solubility or mobility of contaminants. Ex-situ stabilization generally involves excavation of the solids, mechanical mixing of the solids with stabilizing agents, curing of the mass for optimal leach resistance and geotechnical properties, followed by onsite or offsite disposal of the stabilized mass. A variety of stabilization agents are available, including cement, fly ash, silica, bentonite, and various polymers. The types and combinations of stabilization agents that are effective for a particular waste depend on the chemical and physical characteristics of the solid. Stabilization/fixation may be applicable to smaller volumes of overburden used in the cover process to aid in immobilizing contaminants in the upper portions of the overburden. Stabilization/fixation is potentially implementable and is retained for further evaluation.

Dewatering – Dewatering is most effective for separating liquid and solid media for further treatment or disposal. Dewatering is not applicable for large volumes of overburden material; therefore, this process option is not retained.

Separation – Physical separation is a process whereby soils are slurried and passed through a gravity separation process to extract inorganic constituents. This process is most effective where there is a significant difference in particle size, and the contaminants are present in a narrow range of sizes. It is also effective where free inorganic constituents are present and could be selectively removed. These conditions are not present at the Site. Physical separation is not implementable and is not retained.

Thermal

Incineration – Incineration is a process that effectively destroys organic compounds by applying sufficient energy to convert these compounds into nontoxic constituents (e.g., water and carbon dioxide). Incineration is not applicable for inorganic constituents such as selenium in solids and soils; therefore, this technology is not retained.

Desorption – Desorption is a process by which volatile compounds are separated or recovered from a solid matrix. These separation process options are effective for organic constituents but are not effective for inorganic constituents. Desorption is not appropriate for use at the Site and is not retained.

Chemical

Oxidation/Reduction – Similar to the ex-situ treatment of water, oxidizing agents could be applied to solids and soils to react with contaminants reducing them to a less toxic or mobile form. The ex-situ version of this process is achieved by excavating the solids, and slurrying them in a reactor with the oxidizing agent. These reactions could be effective in detoxifying hazardous sludge containing both organics and inorganics. Common oxidizing agents used for sludge treatment include hydrogen peroxide, chlorine, and ozone. This treatment would not be applicable for treating contaminants as a stand-alone technology but could be used in conjunction with other treatment options to reduce the toxicity of process solids. Oxidation/reduction is potentially implementable and is retained for further evaluation.

Hydrolysis – Hydrolysis is a process in which contaminants react with hydrolyzing agents such as mineral acids or alkaline solutions, resulting in the decomposition of the chemical compounds. It is widely used for treating organic wastes but is not feasible for removing selenium or other inorganic chemicals. Hydrolysis cannot be implemented technically and is not retained.

Extraction – Extraction is generally a multistage, counter current, intense scrubbing circuit in which contaminated soil or sludge is excavated/dredged, screened, attrition scrubbed, washed with a surfactant, and separated. The application of extraction has been demonstrated for soils contaminated with petroleum hydrocarbons and/or wood treating chemicals. Extraction is not a proven method for treatment of inorganic constituents and further research may be required for those applications. Extraction is considered potentially implementable with additional research and is retained for further evaluation.

Biological

Enhanced Biodegradation – Biological treatment of solids and soils consists of enhancing the biological degradation of constituents by microorganisms. Ex-situ biological treatment is typically implemented by slurrying solids with the nutrient additives needed to create favorable conditions for the desired microbial activity. Biological treatment of solids has been proven to be most effective for the treatment of hydrocarbons and other organic constituents. The technology is not implementable for the removal, or fixation of inorganic constituents in solids, and is not an appropriate treatment option for solids at Smoky Canyon Mine. Therefore, enhanced biodegradation is not retained.

4.4.7.2 In-Situ Treatment

This section provides more detailed information about the in-situ treatment options being evaluated, and the preliminary screening of each technology for implementability.

<u>Groundwater and Surface Water</u>

Chemical

Chemical Injection – Chemical agents are directly injected into the impacted region of the aquifer to treat the groundwater. The injected chemical agent interacts with the constituents in the groundwater plume to neutralize, precipitate, immobilize, fixate, or destroy the contaminants. General limitations of this technology include the possibility of displacing chemicals to adjacent areas due to the added volume of the chemical solution, and the production of hazardous compounds by reaction of the injected agents with constituents other than the treatment target. Because of the Site conditions for groundwater (e.g., deep aquifer and fractured flow), and the properties of selenium and arsenic, chemical injection is not a viable technology for the Site and is eliminated from further consideration.

Biological

Biodegradation – In-situ biological treatment of groundwater and surface water uses similar scientific principles as ex-situ biological treatment and is primarily achieved by enhancing conditions within the contaminated plume to favor native microorganisms that can metabolize the target contaminants. In most situations in-situ biodegradation is most successful where the geochemical environment and hydraulic conditions allow for control of the key growth variables (e.g., temperature, pH, and nutrients).

Permeable reactive barrier (PRB) technology is an in-situ permeable system that uses reactive media designed to passively treat intercepted contaminated surface water or groundwater. The type of reactive material selected for the PRB depends on local hydrogeologic conditions, and types of contaminants. The reactive media is placed in a trench across the water-bearing zone to be treated. The trench is aligned perpendicular to flow such as to intercept and treat contaminated water. Chemical reactions between the reactive media and contaminated water flowing through the media results in transformation or immobilization of the contaminants.

Unlike conventional pump-and-treat systems, PRBs do not require treatment equipment reliant on access to power and other infrastructure. The technology is capable of successfully treating many inorganic contaminants. To treat selenium, PRBs rely on reactive media that use chemical and microbial processes to chemically reduce and transform selenium from selenate (SeO_4^{-2}) to selenite (SeO_3^{-2}) and ultimately to elemental selenium (Se0). Elemental selenium (Se0) precipitates out of solution and is not bioavailable as an insoluble element. Reactive material suitable to treat selenium include inert sand, wood chips, and alfalfa hay. Various factors influence the reduction speed of microbial processes, including pH, temperature, and salinity.

A subsurface semi-passive remedial technology (PRB) is currently being tested by Monsanto at the toe of the Horseshoe ODA at the South Rasmussen Mine. The current installation consists of an excavated trench that is backfilled with structural backfill material, a short-term carbon source, and long-term carbon source. The alluvial flow system in the area ranges between near surface to 20 bgs. Maximum trench depth is 20 feet. Silica sand is used as the structural backfill material, alfalfa is used as the short-term carbon source, and wood chips are used as the long-term carbon source. The three elements are mixed according to the design ratio (1:1:1) by the loader and are then deposited into the trench. The design also includes installation of some conduit pipes that would allow for supplemental carbon sources to be added to the system, if needed.

In-situ biological treatment is applicable to inorganic constituents in groundwater and surface water and is retained for further evaluation.

<u>Solids and Soils</u>

Physical

Stabilization/Fixation – In-situ stabilization/fixation is performed by using special machinery to directly inject stabilizing agents, such as cement, into the soil. Types of equipment and methods used to deliver the stabilization agents into soils include rotary injection augers, jet grouting, and pressure grouting. In-situ stabilization and fixation have similar advantages and disadvantages to ex-situ treatments. Although stabilization/fixation may not be implementable for large volumes of overburden material, it may be applicable for immobilizing small volumes of material as part of the cover process and is retained for further consideration.

Aeration – Aeration of soils is typically achieved using soil vapor extraction systems. These systems apply a vacuum to subsurface wells to enhance the volatilization process for organic compounds. This treatment technology is not applicable to the inorganic contaminants at the Site and is therefore not retained.

Thermal

Vitrification – Vitrification is a thermal treatment process that immobilizes inorganic compounds and destroys organic compounds by electrically heating and fusing the soil into a stable, glass-like block. Vitrification is potentially implementable and is retained for further consideration.

Desorption – Thermal desorption is similar to aeration, with the addition of a heat source to aid in the volatilization process. As previously discussed, this type of technology is not effective for the treatment of selenium or other inorganic constituents, and therefore, is not appropriate for use at the Site and is not retained.

Biological

Enhanced Biodegradation – In-situ biological treatment of solids uses the same principles as ex-situ biological treatment, except that the solids are not removed and are instead treated in place. It consists of enhancing the biological degradation or reduction of constituents by microorganisms. This process has not been demonstrated to be effective as a treatment for selenium or other inorganic constituents in soils; therefore, this technology is not appropriate for the Site and is not retained.

Phytoremediation – Phytoremediation involves the use of vegetation for the in-situ treatment of contaminated soils and sediments. Plants can directly uptake some organic and inorganic constituents and accumulate them in the plant tissue. Due to the presence of grazing livestock and wildlife in the vicinity of the Site, phytoremediation would not be an appropriate technology and is not retained.

4.4.8 Monitored Natural Attenuation

Groundwater flow causes physical mixing, dilution, and dispersion of contaminants in groundwater. Those physical processes result in decreasing contaminant concentrations with distance along a flow pathway. Sorption and biologically-mediated MNA processes are dependent on geochemical conditions in the Wells Formation aquifer and alluvial flow system at the Site. Under mildly reducing conditions, selenite (SeO_3^{2-}) is the dominant form of selenium in water. When conditions are oxidizing, selenate (SeO_4^{2-}) is the dominant form of selenium. In general, selenate is less strongly sorbed to mineral surfaces than selenite.

Hay et al. (2016) evaluated the release and subsequent transport of selenium from overburden at multiple phosphate mines in southeastern Idaho, with a particular emphasis on understanding conditions leading to selenium attenuation. They compared the results of saturated and unsaturated column tests with groundwater quality data and demonstrated that the ratio of aqueous selenium to aqueous sulfate can be a useful metric for understanding selenium release and attenuation. Hay et al (2016) hypothesized that selenium released in the oxic upper portions of overburden disposed in backfilled pits and large external overburden piles can be subsequently attenuated via reductive precipitation at depth in unsaturated, low oxygen portions of the waste shale. Hay et al. reported that selenium attenuation was not observed in overburden disposed at the Smoky Canyon Mine, and they attributed the lack of selenium attenuation to relatively high oxygen concentrations measured in pore gas samples collected from Panel A and Panel D backfilled pits, where the oxygen content of pore gas remained near atmospheric levels at depths of more than 300 feet below the surface. Based on this study, the selenium species released from ODAs at Smoky Canyon is expected to be predominantly the more oxidized, selenate form.

Attenuation of cadmium and selenium transport by groundwater flow was evaluated as part of the groundwater impact analysis conducted for the Panels F and G EIS (Buck and Mayo 2005; NewFields 2006b). The empirical data presented in these studies demonstrate that both cadmium and selenium experience attenuation during groundwater transport, with cadmium being more highly attenuated than selenium. The potential for attenuation of other mobile constituents of shale overburden, including selenium, was also evaluated in support of similar impact analyses conducted for Monsanto's Blackfoot Bridge Mine (Whetstone 2010) and Agrium's Dry Valley Mine (Enviromin 2006). Each of these studies also found that selenium may be attenuated during groundwater transport within the Wells Formation aquifer by sorption to mineral solids present in the Wells Formation limestone.

The fate and transport of selenium in groundwater at the Site was evaluated during the Site Investigation (NewFields 2005), the RI (Formation 2014c), and during preparation of the Panels F and G EIS (NewFields 2006b). Selenium is typically present in groundwater as selenate, with minor selenite present at some locations including ODA seeps. Site-specific batch-sorption tests (NewFields 2006b) indicated that some selenium was removed from D-Panel seep water when that water was in contact with Wells Formation. The selenium in the seep water was predominantly selenate with lesser selenite (approximately 15 percent of selenium in solution). Therefore, although the geochemical characteristics of groundwater at the Site are typically oxidizing, and the dominant selenium species present is the relatively mobile form, selenate, attenuation of selenium transport may take place within the Wells Formation. However, based on the observed distribution of selenium in groundwater across the Site, it appears that the geochemical attenuation mechanism demonstrated by the batch-sorption tests does not limit the extent of selenium transport from source areas, and natural attenuation may offer only limited reductions in selenium concentrations in groundwater downgradient of those sources. MNA is retained in conjunction with other GRAs for further evaluation.

4.5 Screening of Remedial Technologies and Process Options for Effectiveness, Implementability, and Relative Cost

Each of the technically implementable remedial technologies and process options retained from the initial screening process presented in Section 4.4 were further evaluated to determine whether they should be eliminated from consideration or retained for additional screening by media. Technologies or process options were qualitatively evaluated for effectiveness, implementability, and relative cost. The criteria used for this evaluation are as follows:

<u>Effectiveness</u>

Effectiveness of a remedial technology or process option is evaluated on the potential effectiveness in handling the estimated volume of overburden solids and soil and groundwater and surface water and on meeting the objectives identified in the RAOs. Potential impacts to human health and the environment during construction and implementation are considered. The evaluation also considers whether the remedial technology or process option is proven effective for the conditions at the Site.

<u>Implementability</u>

Technically implementable remedial technologies and process options retained from the initial screening are evaluated for technical and administrative feasibility. Remedial technologies and process options that were clearly ineffective and were therefore not applicable or not feasible were eliminated during the initial screening. In this evaluation, implementability focuses on the ability to obtain permits for offsite remedial actions, administrative and institutional feasibility, the availability and capacity of treatment and disposal services, and the availability of necessary equipment and workers to implement the technology.

<u>Relative Cost</u>

Cost has a limited role in the screening of remedial technologies and process options. Relative capital and O&M costs are used rather than detailed cost estimates. The cost analysis is evaluated based on engineering judgment and is ranked relative to other process options (i.e., low, moderate, high cost) in the same remedial technology type. Because remedial alternatives and associated quantities are not defined during this screening evaluation, relative cost is provided qualitatively rather than quantitatively. The greatest differences in costs are generally associated with different technology types. Cost differences of different process options within a technology type are usually less significant.

Each of the remedial technologies and process options retained from the initial screening were evaluated against the three criteria to determine whether they should be eliminated from further consideration in the FS or retained for additional media-specific screening. A summary of the results of the evaluation process are shown in Figure 4-3. Remedial technologies or process options with low effectiveness, low implementability, and/or relative high cost are eliminated from further consideration and are not used to develop remedial alternatives. These process options are shaded gray. The specific location where implementation of a retained process option is applicable is also considered during the evaluation and is briefly described. The screening is described in the following subsections.

4.5.1 No Further Action

The No Action alternative is required for consideration by the NCP and is retained. Because previous work has occurred at Smoky Canyon, this alternative is No Further Action.

4.5.2 Institutional Controls

Institutional controls are administrative and legal mechanisms that help to minimize the potential for exposure to contamination and/or protect the integrity of a response action. They may be used alone or in conjunction with other alternatives as part of an overall remedy and are meant to supplement engineering controls during all phases of cleanup and may be a necessary component of the selected remedy.

The land where mining activities have occurred at the Site (and where the source areas are located) is federal land managed by the Caribou-Targhee National Forest. As such, land-use controls such as Forest Service closure orders may be used by the Forest Service to prevent access to the Site or prevent activities that could compromise the integrity of remedial actions. The Forest Service administers several grazing allotments that encompass portions of the Site. Land managers use grazing management plans as tools to protect water quality, forage, and beneficial use. Grazing controls are often included as a BMP temporarily during implementation of the final remedy. Controlling domestic livestock grazing would allow establishment of vegetation on recently seeded areas. Land-use controls and grazing controls are easily implementable, would be effective at a relatively low cost, and are retained for further screening by media.

Simplot owns the land in Sage Valley and therefore could implement deed restrictions to prevent future activities that would present a risk. Deed restrictions are easily implementable, would be effective at a relatively low cost, and are retained for screening by media.

Enforcement and permit tools such as administrative orders, federal facility agreements, and consent decrees could be effective to limit certain activities or require the performance of specific activities such as monitoring or reporting on effectiveness. Administrative orders and consent decrees are legally binding and could be enforced at a relatively low cost. These enforcement options are retained for screening by media.

Public information programs would be effective to restrict activities that could compromise remedial actions. For example, during the period that cover systems vegetation is maturing, it would be appropriate to inform the public that access is restricted until certain components of the remedy are complete. Signs could be an effective method of providing information. In the future, the Forest Service may elect to post warnings signs to inform the public about the residual contamination present at the Site. Public information programs and warning signs are easily implementable institutional controls and would be moderately effective at a relatively low cost and are retained.

These process options are all retained for further screening by media.

4.5.3 Access Controls

Access controls include physical barriers such as fences and gates to limit access to source areas at the Site (e.g., ODAs or seeps or springs).

These controls would be appropriate for preventing access during implementation of remedial actions and until they are effective. For example, fences could be used to restrict access to seeps and detention basins with selenium and arsenic concentrations above levels of concern and would be effective while control of the sources is being implemented and until source control becomes effective (which will reduce concentrations in the seeps and detention basins).

Physical barrier process options are all retained for further screening by media.

4.5.4 Containment

Various cover types, as well as encapsulation of seleniferous material, are discussed in the Selenium Management Practices document (SeWG 2005). Simplot identified source areas and available volumes of the primary material types to be evaluated for use in CERCLA cover systems that are considered for the FS (Formation 2016b).

Dinwoody covers have already been used extensively at the Site for post-mining reclamation. They are effective in preventing direct contact to overburden materials and in reducing infiltration of water (and thereby reducing the subsequent release of selenium and transport to soils, groundwater and surface water). The Pole Canyon ODA 2013 NTCRA entailed installation of a 3-foot thick Dinwoody cover over a 2-foot thick layer of chert/limestone. This cover was selected for the NTCRA by an EE/CA evaluation which showed that it would be effective in protecting human health and the environment. In addition to being used as a thick barrier layer to prevent vegetation from rooting in overburden materials, chert/limestone could be used as a water conveyance layer in a more complex cover system (i.e. geosynthetic clay liner [GCL], Dinwoody or tailings).

Another possible configuration is a monolithic Dinwoody storage layer that can act as a "water balance cover". Water balance covers tested in field demonstrations in semi-arid climates (e.g., Montana and Utah) are hydraulically equivalent to the geosynthetic cover (Albright et al. 2004). The monolithic soil storage layer is effective in storing and releasing snow melt and rain water and does not rely on the physical characteristics of a single design element (i.e., the low hydraulic conductivity barrier). Although the water balance cover is thicker than a soil or geosynthetic cover, soil placement methods are implementable and less labor intensive than construction of a hydraulic barrier layer or placement of a geomembrane, resulting in a lower relative cost.

Dinwoody and chert/limestone covers are proven, effective materials, and are retained for screening by media.

Simplot also identified tailings as a potential component of an ODA cover system because of its low hydraulic conductivity and subsequent effectiveness in reducing infiltration into underlying overburden materials (Formation 2014b). Because the material could be highly-erodible on an ODA slope it is not implementable as a surface material but could be used as a subsurface layer (for example beneath a chert/limestone layer that would provide physical protection and stability). A large quantity is available in the tailings impoundments and more is generated each year by active mining. Tailings material is retained for use as a subsurface layer in cover systems on ODAs.

Soil covers can provide a physical barrier between the vegetation root zone and ODA materials, thus reducing the potential for selenium uptake by selenium-accumulating plants along with preventing direct contact and ingestion by potential receptors. However, Dinwoody is present at the Site, is proven implementable, and can support vegetation in a similar manner to soil. Sufficient quantities of soil for ODA covers would be more difficult to obtain and have a higher cost because of longer transportation distances. Because it is less effective, less implementable, and comes at a higher cost than Dinwoody material, a soil cover is screened out from further consideration in the FS.

Geosynthetic covers consist of multiple layers and may include a GM or GCL. Other materials such as Dinwoody and chert/limestone would also be used in a GM/GCL cover to provide growth media for vegetation and stability/drainage. The GCL technology has been implemented successfully in the Southeast Idaho Phosphate Mining Resource Area: notably at South Maybe Canyon Mine (a CERCLA action on a cross-valley fill ODA) and at the Blackfoot Bridge Mine (as part of active mining). Therefore, this option is retained for screening by media.

Sediment control features such as dikes and berms and detention basins already in place at the Site are effective in preventing storm water runoff from mining areas from reaching local creeks. These features would be maintained as needed. Additional features may be constructed to support installation and operation of new covers on Panel A and Panel D, and therefore, these process options are retained.

With the exception of soil covers, all engineered cover process options and sediment control features are retained for further screening by media.

4.5.5 Source Control, Flow Control and Routing

Surface control process options considered for use at the Site include grading, erosion control and protection, and vegetation. Grading could be used during cover installation to provide a surface that promotes runoff and thus reduces infiltration. Grading will be needed for covers at Panel A and Panel D to eliminate areas where pooling of water currently occurs. Erosion protection consists of the use of erosion-resistant materials such as riprap, vegetation, and geosynthetic fabrics to reduce or eliminate erosion of solid media by storm water runoff. These materials are usually installed after regrading of the surface has been performed and have been used at the Site. These process options will be used as necessary in the design of cover systems. Establishing a vegetative cover is a standard surface reclamation technology for covers on ODAs and has been implemented successfully at the Site. Vegetation will be used at the surface of any cover system installed on ODAs.

Slope stabilization technology includes slope reduction (by grading) and retaining walls to reduce erosion and sediment transport. Both process options were used in the Pole Canyon ODA 2013 NTCRA and the option could be used in cover installation at other ODAs (to be determined during remedial design).

Diversion consists of routing or managing flow within open channels or closed conduits. This process option was used in the 2006 NTCRA at the Pole Canyon ODA to convey the flow in Pole Canyon Creek around the ODA. For future work, this process option may be used as part of the design of cover systems on the Panel A and Panel D ODAs to manage storm water.

Source control, flow control and routing process options are all retained for further screening by media.

4.5.6 Removal and Disposal

Remedial technologies for the removal and disposal GRA for overburden solids and soils include excavation of solids and soils, and disposal or consolidation either onsite or offsite. Technologies for removal and disposal of contaminated groundwater are limited to extraction wells and discharge to an onsite treatment or other storage/disposal facility.

Complete source removal is not implementable or effective for pit backfill and external ODAs. The material volume is large (millions to tens of millions of cubic yards) and no suitable location exists for disposal. Also, the resultant disposal area would have similar environmental conditions and issues as for the current pit backfill and ODAs. Similarly, offsite disposal of large volumes of material would not be more effective than source control actions and would entail orders of magnitude higher cost.

However, source removal could be effective for small volumes of materials. For example, once source controls (i.e., ODA covers) are implemented and are effective, residual sediment remaining in seep areas or storm water/seep detention ponds could be removed and consolidated onsite. This could be an effective method to manage residual risk after source controls are complete. Similarly, residual solid materials generated by water treatment, could be consolidated onsite if their chemical properties were suitable. If the residual materials were characterized as hazardous waste, then the materials would require offsite disposal in a hazardous waste landfill.

Extraction wells could be used to capture groundwater and control gradients and flow direction. Multiple extraction wells could be installed along preferential pathways and along the West Sage Valley Branch Fault. Extracted groundwater could be treated and discharged or reintroduced. The RI, however, demonstrated that groundwater flow within the Wells Formation is influenced by preferential flow paths. In fact, placement of a Wells Formation well within zones of high transmissivity and high concentrations of COCs is difficult. Monitoring wells GW-18 and GW-24 are examples. These Wells Formation monitoring wells were placed near the West Sage Valley Branch Fault and downgradient of the Pole Canyon ODA and Panel E, respectively. The Wells Formation at GW-24 is low transmissivity while GW-18 is in a high transmissivity zone. Concentrations of selenium in groundwater samples collected from GW-18 and GW-24 are below the MCL for selenium. Moreover, GW-18 is located less than 700 feet upgradient of Hoopes Spring where the maximum observed selenium concentration is approximately 10 times observations at GW-18. The presence of preferential flow paths was further demonstrated by the range of observed selenium concentrations from discrete springs sampled at Hoopes Springs during the RI.

In short, use of extraction wells upgradient of Hoopes Springs is unlikely to be effective due to known hydrogeologic complexities. Moreover, Hoopes Springs acts as a regional groundwater discharge feature, which effectively captures the migration of COCs within Wells Formation groundwater in the southern groundwater flow system. Extraction from pumping wells similar to the Industrial Well would be moderately effective and fairly easy to implement but would have a relatively high cost. Extraction wells are retained as a technology for screening by media.

Another retained process option for this remedial technology is routing groundwater that discharges at the springs complex to a water treatment facility. This is being implemented in the water treatment pilot study and additional conveyance systems may be installed to maintain the required influent flow and quality to any treatment system. Groundwater or surface water could also be routed to a storage/disposal facility.

Removal and disposal technologies/process options retained for further screening by media include excavation of solids and soils and disposal or consolidation onsite or disposal offsite, and extraction or routing of groundwater and surface water and disposal through surface discharge (e.g., retention ponds) or subsurface injection (e.g., reinjection well or infiltration basin).

4.5.7 Treatment

Groundwater and Surface Water

The principal treatment technology for removing selenium is biological treatment. Two pilot scale biological treatment systems have been evaluated at the Site. The first system was a semi-passive, buried, anaerobic, bioreactor used to treat a low flow, high concentration toe seep (seep DS-7) from one of the ODAs. The initial pilot system operated for approximately 7 months and achieved a selenium removal efficiency between 72% and 97% (Moller 2002). This pilot unit was refitted in 2013 and used for about 2 years. Overall, the treatment system achieved a selenium removal efficiency of 56% (Formation 2016c). The system was supposed to be semi-passive with little maintenance required; however, it was more difficult to operate during the winter due to freezing within the bioreactors and required significant maintenance during spring restart. Although this semi-passive system has moderate effectiveness for removing selenium and is difficult to implement in remote locations during the wintertime, it is retained for screening by media because it is implementable for a low to moderate cost.

The second biological treatment pilot study is a larger scale, active water treatment plant, located between Hoopes Spring and South Fork Sage Creek springs. The plant consists of an anaerobic fluidized bed bioreactor which contains media that hosts a film of bacteria that specifically target selenium for their biological metabolism. Phase 1 of the pilot study operated from March 2016 to March 2017. A second fluidized bed bioreactor unit was added in conjunction with an ultrafiltration/reverse osmosis system for Phase 2 in order to treat higher flows (Formation 2017). The Phase 2 pilot study system began operating in February 2018 and is ongoing. Initial data indicate that the active fluidized bed bioreactor is capable of achieving 80% to 90% removal.

Other process options may be required to support the biological treatment system, as determined by design and operations testing. These include gravity separation (settling of suspended solids in ponds, basins, or tanks), mechanical separation (such as belt presses, filter presses, and vacuum filtration units), media filtration (typically using sand), ultrafiltration/reverse osmosis (separation of contaminants by semipermeable membrane), chemical precipitation (precipitation of dissolved ions/salts in the form of insoluble salts), and/or chemical oxidation or reduction to improve selenium removal efficiency. While these options are retained in the FS process, they are not stand-alone technologies, rather options to improve the selenium removal by the biological system.

Several process options evaluated for effectiveness, implementability, and relative cost were not retained for development of remedial alternatives in the FS including ion exchange, and adsorption using activated carbon or metal oxides.

Ion exchange was initially retained as a potentially implementable treatment technology. However, the process has not been tested in conditions similar to those found at the springs complex and due to uncertain effectiveness and relatively high cost, ion exchange is screened out of further consideration.

Carbon adsorption is implementable and is an effective method of removing organic constituents; however, it is only moderately effective for removal of low concentrations of arsenic and is ineffective for the removal of selenium. Overall performance typically is related to water chemistry. While carbon adsorption may be potentially implementable, it has low to moderate effectiveness for inorganic contaminants and a relatively high cost. Therefore, carbon adsorption is not retained.

Metal oxides are capable of selective metal adsorption. A pilot scale study was performed at the Site to test the effectiveness of a zero-valent iron, metal oxide adsorption system (Formation 2012e). Zero-valent iron was selected over the more common activated alumina due to the potential for the iron media to more effectively remove selenium than the alumina. Selenium concentrations in the pilot influent ranged from 0.035 to 0.050 mg/L. The 24-gpm system only achieved an average selenium reduction of 40% to 50% (not sufficient to meet surface water quality criteria). This study demonstrated that the technology would not be effective at consistently reducing selenium concentrations to levels that would meet Site PRGs and is therefore not retained.

Biodegradation is retained for further screening by media as a primary process option for treatment of groundwater and surface water.

<u>Solids and Soils</u>

In-situ or ex-situ stabilization/fixation involves injecting stabilizing agents, such as cement, into the soil or excavation and mechanical mixing of solids with stabilizing agents. While this process may not be implementable for large volumes of overburden material, it may be applicable for smaller volumes. Stabilization/fixation is implementable and could be effective for immobilizing small volumes of material as part of the cover process and is retained for screening by media in conjunction with cover process options.

Extraction is implementable and is effective for removal of organic constituents from solids and soils but is not a proven treatment method for inorganic constituent removal. Further research may be required, which would increase the relative cost of this technology. Using extraction on large volumes of overburden material would also result in higher relative costs. Extraction is not an appropriate process option and is not retained.

Physical stabilization/fixation is retained as a process option for treatment of solids and soils for screening by media.

Vitrification is a thermal treatment process that immobilizes inorganic compounds in solids and soils. Although thermal vitrification could be effective, due to the large volumes of overburden present at the Site the process would have low implementability and relatively high costs; therefore, vitrification is not retained.

4.5.8 Monitored Natural Attenuation

MNA is a natural physical, chemical, and/or biological treatment process that may be used in conjunction with the above-mentioned technologies and process options to achieve remedial objectives for groundwater and is retained for further evaluation.

4.6 Remedial Technologies/Process Options Retained for Further Evaluation

Based on the results of the two-step screening process described in Sections 4.4 and 4.5, the remedial technologies and process options within each GRA that are retained for further evaluation by media are summarized in Table 4-3. Evaluation and selection of representative technologies and process options for solids and soils, groundwater, and surface water is presented in Section 5.

TABLE 4-1. Water Flow and Selenium Concentrations at Overburden Seeps

Seep	Date	Flow (cfs)	Selenium, Total (mg/L)	Selenium, Dissolved (mg/L)
Panel A				
AS-1	5/14/2002	0.22	0.005 J	0.005 J
AS-2	5/25/2003	0.004	3.1	3.15
	5/18/2004	---	3.62	3.78
Panel D				
DS-7	5/17/2016	0.008	4.73	4.51
	11/8/2016	---	3.64	3.66
	5/16/2017	0.0041	4.88	4.59
DS-10	5/25/2003	0.00002	1.05	1.09
Panel E				
ES-3	5/17/2016	0.0078	0.0062	0.0062
	11/8/2016	---	0.0067	0.0074
	5/16/2017	0.0033	0.0068	0.0059
ES-4	5/19/2008	0.007	11.2	11.9
	6/2/2009	---	23.4	23.4
	5/7/2015	---	26.1	18.7
ES-5	5/7/2004	0.013	1.66 J-	1.61 J-
	7/23/2004	0.01	3.26	2.62
	9/19/2005	0.001	15	11.4
Pole Canyon				
LP-1 [1]	5/15/2017	0.21	3.72	3.79
	8/1/2017	0.064	4.12	4.03
	11/13/2017	0.0072	3.31	2.85

Notes:
cfs - cubic feet per second
mg/L - milligrams per liter

1 - Flow at LP-1 will likely decrease as effects from the Non-Time-Critical Removal Actions are realized.

TABLE 4-2. Selenium Concentrations at Detention Basins

Detention Pond	Date	Selenium, Total (mg/L)	Selenium, Dissolved (mg/L)
Panel A			
AP-2	5/25/2003	2.1	1.07
	7/22/2004	0.101	0.0941
AP-5	5/12/2012	0.007	0.007
	6/21/2012	0.0076	0.0075
	9/26/2013	0.0038	0.0033
AP-6	3/31/2005	0.019	0.0177
AP-13	6/21/2012	0.0288	0.0284
	4/11/2013	0.47	0.039
	9/26/2013	0.0107	0.0091
AR-1	5/3/2006	0.00044	0.00038
	9/18/2006	0.0012	0.00088
	6/3/2008	0.00086	0.00058
Panel D			
DP-1	7/26/2004	0.0044	0.0015
DP-2	7/27/2004	0.0022 U	0.002
DP-3	7/27/2004	0.0016 U	0.00058 J
DP-7	5/25/2003	3	2.9
	7/22/2004	0.247	0.0906
	9/15/2010	1.6	1.39
DP-10	10/29/2003	0.0359	0.0267 J-
	5/7/2004	0.412 J-	0.309 J-
	7/22/2004	0.338	0.0738
DP-15	7/27/2004	0.0027 U	0.0035 J+
Panel E			
EP-2	7/29/2004	0.0035 J-	0.0017 J-
	7/10/2010	0.0513	0.0424
EP-3	7/23/2004	0.00045 U	0.00034 J+
	7/10/2010	0.0029	0.0023
EP-4	5/21/2003	6.9	7.2
	7/23/2004	2.27	1.69
EP-5	7/23/2004	0.101	0.0898
	7/9/2010	0.0074	0.0054
EP-7L	7/10/2010	0.0016	0.0009
EP-7U	7/10/2010	0.0026	0.002
EP-11	7/29/2004	0.00412	---

Notes:
mg/L - milligrams per liter

TABLE 4-3. Remedial Technologies and Process Options Retained for Further Evaluation by Media

Remedial Technology	Process Option
No Further Action	None
Institutional Controls	Land-Use Controls
	Deed Restrictions
	Administrative Orders/Consent Decrees
	Signs/Information Programs
Access Controls	Fences/Gates
Containment/Engineered Covers	Tailings Cover
	Chert/Limestone Cover
	Dinwoody Cover
	Water Balance Cover
	Geosynthetic Cover (GM/GCL)
Sediment Control Features	Dikes/Berms/Detention Basins
Surface Controls	Grading/Erosion Control/Vegetation
	Slope Reduction/Retaining Walls
Diversion	Open/Closed Channels
Removal	Excavation
	Extraction Wells
Disposal	Onsite Disposal/Onsite Consolidation
	Offsite Disposal
	Onsite Treatment of Other Storage/Disposal Facility
Physical Treatment	Gravity Separation
	Mechanical Separation
	Media Filtration
	Ultrafiltration/Reverse Osmosis
	Stabilization/Fixation
Chemical Treatment	Chemical Precipitation
	Oxidation/Reduction
Biological Treatment	Biodegradation
Natural Physical/Chemical/Biological Process	Monitored Natural Attenuation

FIGURE 4-1. IDENTIFICATION OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION
No Action	None	None
Institutional Controls	Government Controls	Zoning Restrictions, Closure Orders, Grazing Controls, Ordinances, Building Permits
	Proprietary Controls	Deed Restrictions, Easements, Covenants
	Enforcement and Permit Tools	Administrative Orders, Consent Decrees
	Information Devices	Notices, Signs, Information Programs, State Registries
Access Controls	Physical Barriers	Fences
		Gates
Containment	Engineered Covers	Soil Cover
		Tailings Cover
		Chert/Limestone Cover
		Dinwoody Cover
		Geosynthetic Cover
	Barriers	Slurry Walls
		Sheet Piling
		Rock Grouting
	Sediment Control Features	Dikes and Berms
		Detention Basins

FIGURE 4-1. IDENTIFICATION OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

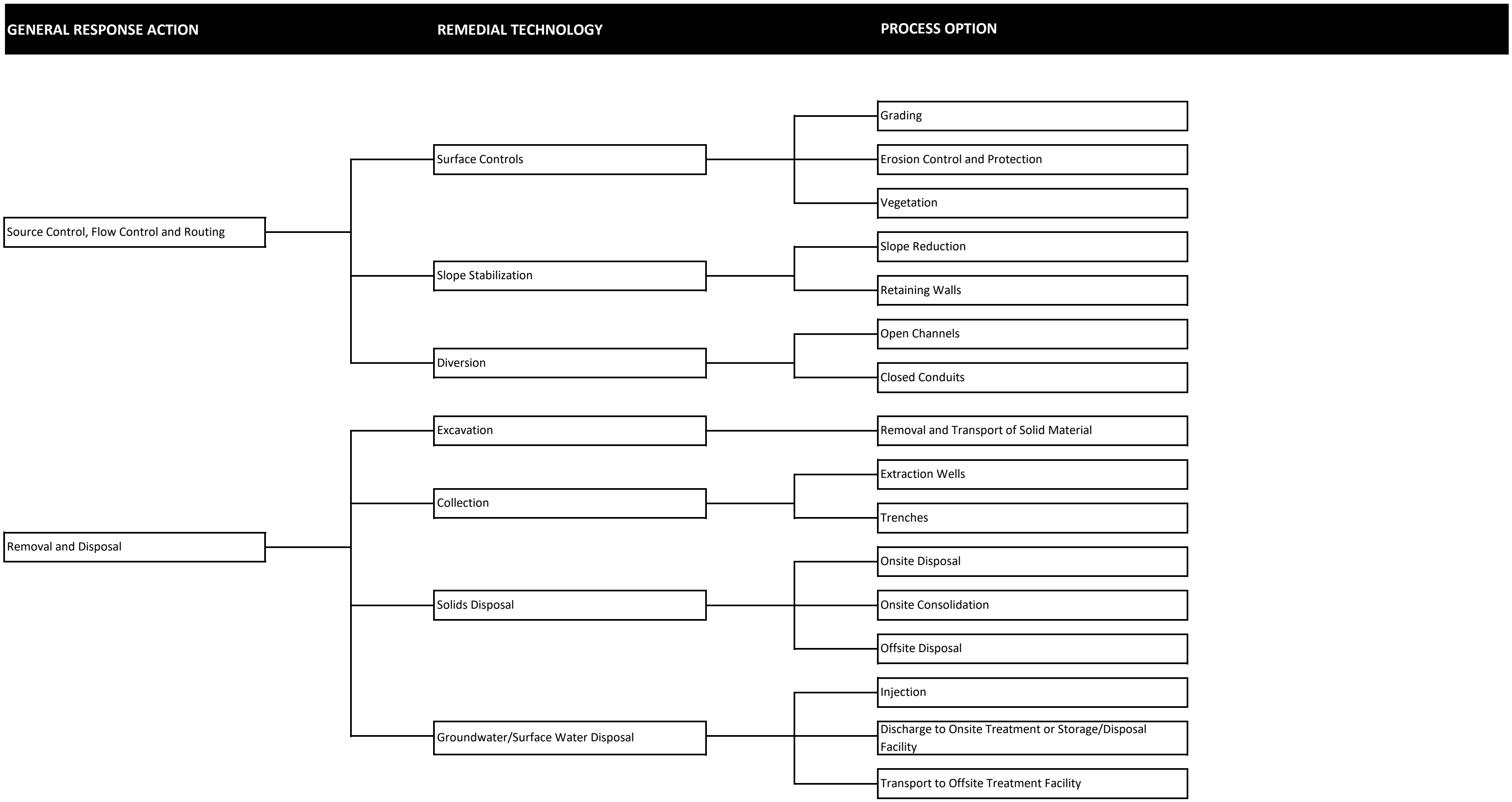

FIGURE 4-1. IDENTIFICATION OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

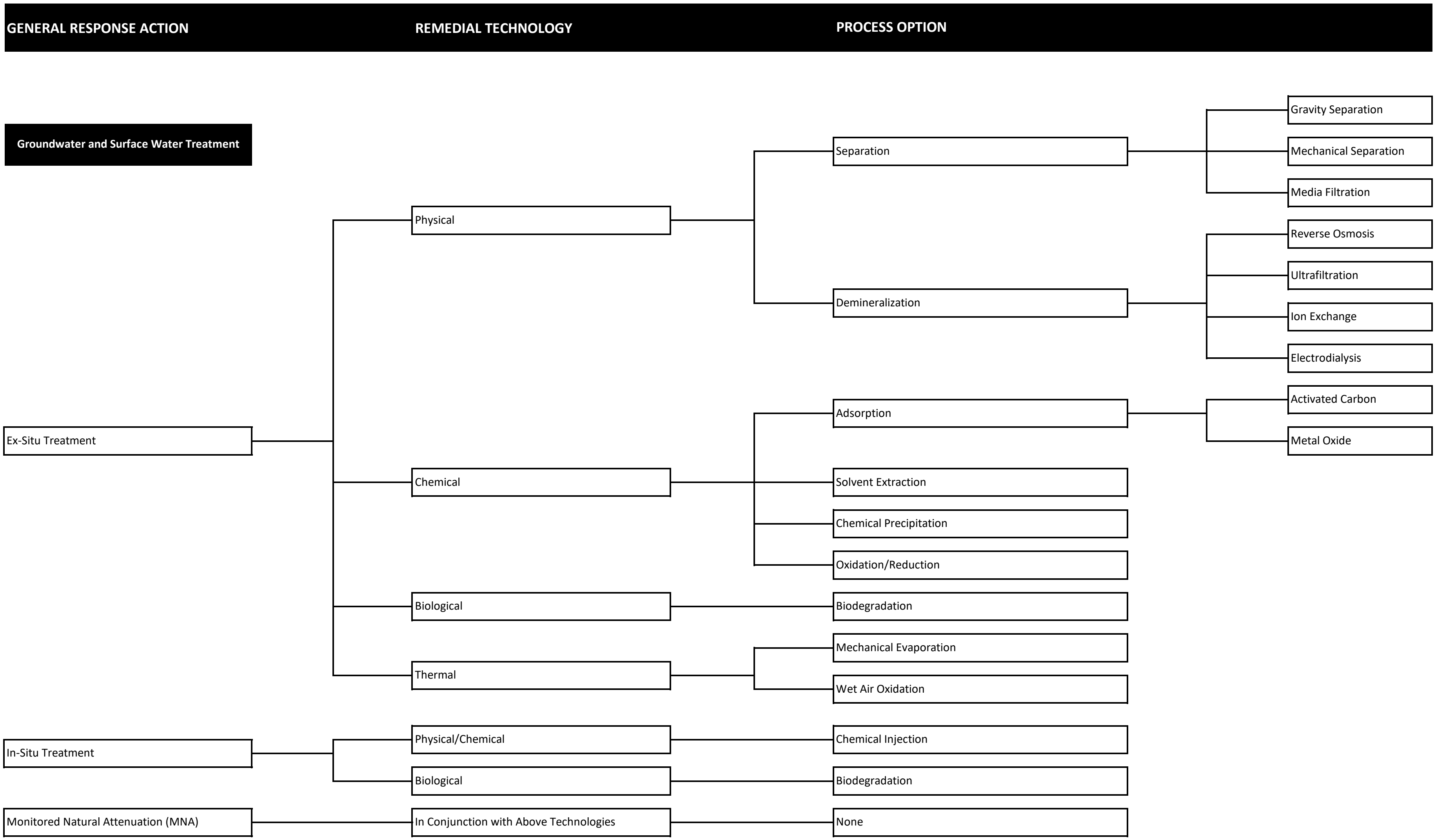

FIGURE 4-1. IDENTIFICATION OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

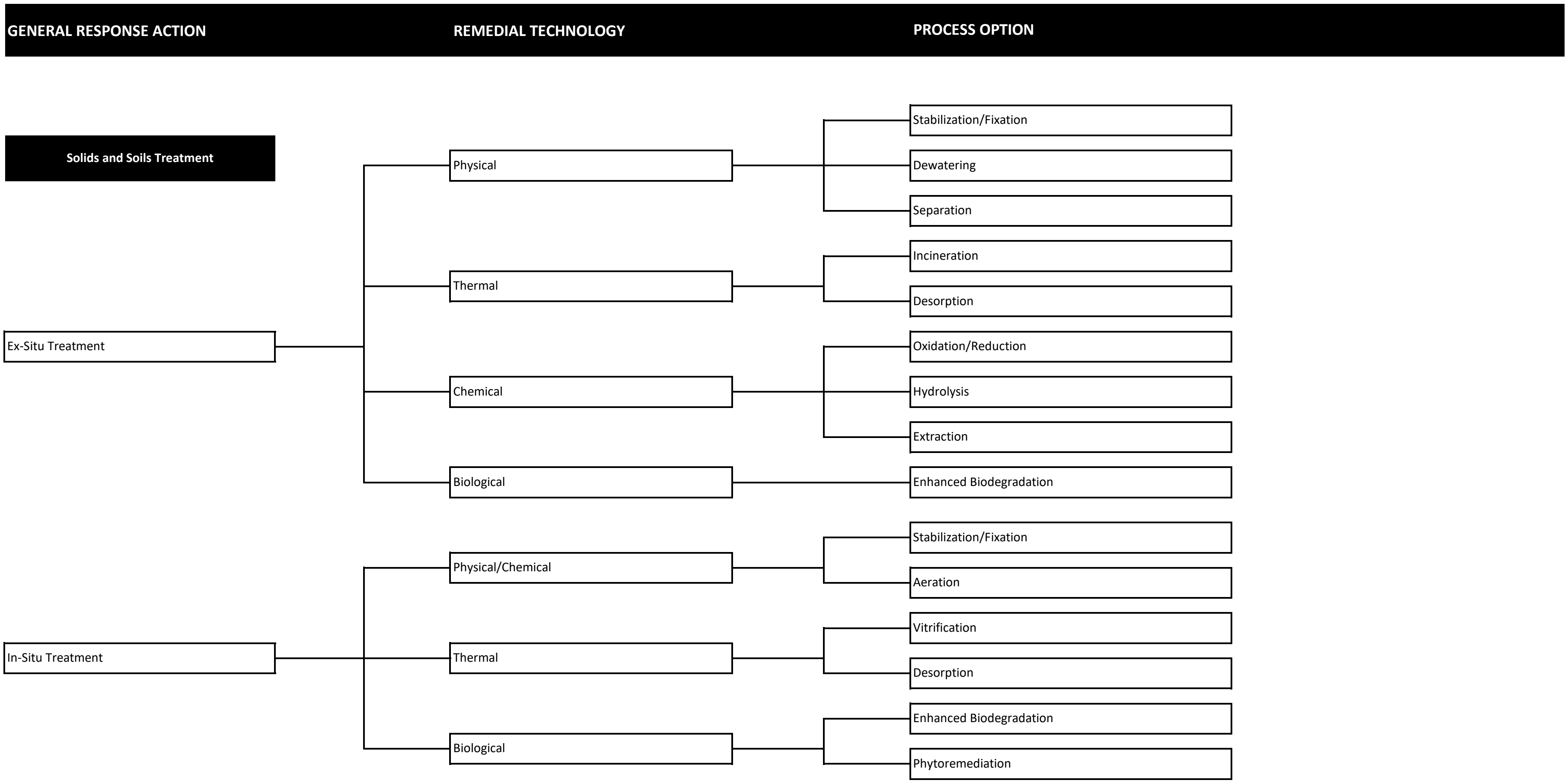

FIGURE 4-2. INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR TECHNICAL IMPLEMENTABILITY

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	PROCESS OPTION	DESCRIPTION	SCREENING COMMENT	SCREENING RESULT
No Action	None	None		No Action. Because previous work has occurred at Smoky Canyon Mine this becomes No Further Action.	No Action required by the NCP as a baseline for comparison.	Retained
Institutional Controls	Government Controls	Zoning Restrictions, Closure Orders, Grazing Controls, Ordinances, Building Permits		Federal, state, or county laws or regulations that restrict or control land or resource use.	Potentially implementable.	Retained
	Proprietary Controls	Deed Restrictions, Easements, Covenants		Deed restrictions prevent use of groundwater as drinking water.	Potentially implementable.	Retained
	Enforcement and Permit Tools	Administrative Orders, Consent Decrees		Legal tools that limit ceratin activities or require the performance of specific activities.	Potentially implementable.	Retained
	Information Devices	Notices, Signs, Information Programs, State Registries		Notification that residual or covered contamination remains at a site.	Potentially implementable.	Retained
Access Controls	Physical Barriers	Fences		Fixed structures that function as boundaries or barriers.	Potentially implementable.	Retained
		Gates		Fixed structures that limit access.	Potentially implementable.	Retained
Containment	Engineered Covers	Soil Cover		Soil cover layer to limit infiltration, reduce seepage, and reduce uptake of selenium by plants.	Potentially implementable.	Retained
		Tailings Cover		Tailings cover layer to limit infiltration, reduce seepage, and reduce uptake of selenium by plants.	Potentially implementable.	Retained
		Chert/Limestone Cover		Chert/limestone layer to provide a capillary break and minimize burrowing and root growth.	Potentially implementable.	Retained
		Dinwoody Cover		Dinwoody cover layer to limit infiltration, reduce seepage, and reduce selenium uptake by plants.	Potentially implementable.	Retained
		Geosynthetic Cover		Clay and synthetic membrane (GCLL or GM) covered by soil to prevent infiltration and reduce seepage.	Potentially implementable.	Retained
	Barriers	Slurry Walls		Trench around ODAs or source materials filled with a soil bentonite slurry.	Not implementable due to the number of sources and depth/extent required to control groundwater.	NOT Retained
		Sheet Piling		Cutoff walls formed of wood, synthetics, pre-fabricated concrete, or steel.	Not implementable due to the number of sources and depth/extent required to control groundwater.	NOT Retained
		Rock Grouting		Pressure injection of grout in drilled holes or using vibrating beam method.	Not implementable because of the depth and extent required to control groundwater.	NOT Retained
	Sediment Control Features	Dikes and Berms		Grading the land surface to control surface water runoff and sediment mobilization.	Potentially implementable.	Retained
		Detention Basins		Basins or ponds used to allow sediment to settle out of storm water runoff.	Potentially implementable.	Retained

Technologies and/or process options screened out

FIGURE 4-2. INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR TECHNICAL IMPLEMENTABILITY

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	PROCESS OPTION	DESCRIPTION	SCREENING COMMENT	SCREENING RESULT
Source Control, Flow Control and Routing	Surface Controls	Grading		Grading the land surface to manage surface water infiltration and runoff.	Potentially implementable in conjunction with other technologies.	Retained
		Erosion Control and Protection		Use of riprap, vegetation, and geosynthetic fabrics to reduce erosion.	Potentially implementable.	Retained
		Vegetation		Application of soil and seeding with native plants to reduce infiltration, runoff, erosion.	Potentially implementable in conjunction with other technologies.	Retained
	Slope Stabilization	Slope Reduction		Reducing the grade of surface slopes of backfilled pits and ODAs.	Potentially implementable.	Retained
		Retaining Walls		Vertical walls of steel, concrete, bricks, wood, or rock to stabilize steep slopes.	Potentially implementable.	Retained
	Diversion	Open Channels		Engineered canals or ditches constructed to convey surface water.	Potentially implementable.	Retained
		Closed Conduits		Culverts or pipes installed below ground to manage and control surface water.	Potentially implementable.	Retained
Removal and Disposal	Excavation	Removal and Transport of Solid Material		Excavation and transport of overburden/soils or sediments using earthmoving equipment.	Potentially implementable in conjunction with other technologies.	Retained
	Collection	Extraction Wells		Pumping well(s) used to control gradients and flow directions and to extract contaminated groundwater.	Potentially implementable.	Retained
		Trenches		Excavated ditches or channels to intercept and manage groundwater.	Not implementable due to the depth of the Wells formation aquifer.	NOT Retained
	Solids Disposal	Onsite Disposal		Identification of an onsite location for disposal of overburden/soils or treatment residuals.	Potentially implementable.	Retained
		Onsite Consolidation		Consolidation and relocation of overburden materials or treatment residuals and backfill/disposal in mine pits.	Potentially implementable for nonhazardous materials.	Retained
		Offsite Disposal		Disposal of hazardous material in a landfill offsite.	Potentially implementable.	Retained
	Groundwater/ Surface Water Disposal	Injection		Disposal of treated water by injection into deep wells.	Not feasible to implement due to discharge of groundwater at creeks and springs.	NOT Retained
		Discharge to Onsite Treatment or Storage/Disposal Facility		Routing and discharge of impacted water to a treatment or storage/disposal facility onsite.	Potentially implementable in conjunction with treatment technologies.	Retained
		Transport to Offsite Treatment Facility		Transport of impacted water to a publicly owned treatment works (POTW) facility offsite.	Not implementable because there are no POTW facilities near the Site.	NOT Retained

Technologies and/or process options screened out

FIGURE 4-2. INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR TECHNICAL IMPLEMENTABILITY

Groundwater and Surface Water Treatment

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	PROCESS OPTION	DESCRIPTION	SCREENING COMMENT	SCREENING RESULT
Ex-Situ Treatment	Physical	Separation	Gravity Separation	Separation of solids from a liquid using settling tanks, basins or other devices.	Potentially implementable in conjunction with other treatment technologies.	Retained
			Mechanical Separation	Separation of solids from a liquid using a mechanical device such as a belt press.	Potentially implementable in conjunction with other treatment technologies.	Retained
			Media Filtration	Separation of solids from a liquid typically using a granular media filter.	Potentially implementable in conjunction with other treatment technologies.	Retained
		Demineralization	Ultrafiltration/Reverse Osmosis	Physical treatment process in which pressurized water passes through a semipermeable membrane.	Potentially implementable in conjunction with other treatment technologies.	Retained
			Ion Exchange	Cation or anion exchange resins used to remove ions from water.	Potentially implementable in conjunction with other treatment technologies.	Retained
			Electrodialysis	An electric field used as the driving force for separating a liquid across a membrane.	Not implementable for inorganic constituents found in groundwater at the site.	NOT Retained
	Chemical	Adsorption	Activated Carbon	Granular media filled vessels used to remove dissolved constituents from groundwater or surface water.	Potentially implementable in conjunction with other treatment technologies.	Retained
			Metal Oxide	Vessels filled with zero-valent iron or activated alumina used primarily to remove arsenic.	Potentially implementable in conjunction with other treatment technologies.	Retained
		Solvent Extraction		Separates constituents from a liquid by contact with another immiscible liquid.	Not applicable to inorganic constituents found in groundwater at the site.	NOT Retained
		Chemical Precipitation		Chemical process where dissolved ions/salts are precipitated in the form of insoluble salts.	Potentially implementable in conjunction with other treatment technologies.	Retained
		Oxidation/Reduction		Chemical reactions used to change contaminants to less toxic compounds.	Potentially implementable in conjunction with other treatment technologies.	Retained
	Biological	Biodegradation		Microorganisms used to degrade or reduce contaminants.	Potentially implementable.	Retained
	Thermal	Mechanical Evaporation		Water is mechanically heated to boiling and clean water is distilled off.	Not feasible due to the large water flow rates.	NOT Retained
		Wet Air Oxidation		Combustion reaction to break contaminated water and constituents down into base reaction products.	Not applicable to inorganic constituents found in groundwater at the site.	NOT Retained
In-Situ Treatment	Physical/Chemical	Chemical Injection		Chemical agents are injected into the impacted region of the aquifer to treat the groundwater.	Potentially hazardous byproducts, and complicated groundwater setting.	NOT Retained
	Biological	Biodegradation		Nutrients are injected into groundwater to encourage native microorganisms to metabolize contaminants.	Potentially implementable for inorganic constituents.	Retained
Monitored Natural Attenuation	In Conjunction with Above Remedial Technologies	None		Natural physical/biochemical processes to further reduce contamination in groundwater.	Potentially implementable in conjunction with other technologies.	Retained

Technologies and/or process options screened out

FIGURE 4-2. INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR TECHNICAL IMPLEMENTABILITY

Solids and Soils Treatment

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	PROCESS OPTION	DESCRIPTION	SCREENING COMMENT	SCREENING RESULT
Ex-Situ Treatment	Physical	Stabilization/Fixation		Excavated solids slurried with stabilization/ fixation agents to reduce contaminant solubility and mobility.	Potentially implementable to immobilize small volumes of solids/soils during the cover process.	Retained
		Dewatering		Separation of liquids from solids by various methods.	Not applicable for large volumes of overburden material.	NOT Retained
		Separation		Soils are slurried, and passed through a gravity separation process to extract inorganics.	Site conditions not conducive to this technology.	NOT Retained
	Thermal	Incineration		Energy applied to solids to combust organic constituents.	Not applicable to inorganic constituents in solids and soils at the site.	NOT Retained
		Desorption		Volatile compounds are separated or recovered from a solid or liquid matrix.	Not applicable to inorganic constituents in solids and soils at the site.	NOT Retained
	Chemical	Oxidation/Reduction		Chemical reactions used to change contaminants to less toxic compounds.	Potentially implementable when used in conjunction with other process options.	Retained
		Hydrolysis		Contaminants react with hydrolyzing agents resulting in decomposition of the chemical compounds.	Not applicable for removing selenium from solids and soils at the site.	NOT Retained
		Extraction		Multistage, intense scrubbing circuit used to wash and separate contaminated solids.	Not a proven method for inorganics but potentially implementable with further research.	Retained
	Biological	Enhanced Biodegradation		Slurrying solids with nutrient additives for degradation of constituents by microbial activity.	Not applicable for inorganic constituents.	NOT Retained
In-Situ Treatment	Physical/Chemical	Stabilization/Fixation		Machinery is used to directly inject stabilizing agents, such as cement, into the soil.	Potentially implementable to immobilize small volumes of solids/soils during the cover process.	Retained
		Aeration		Aeration of soils is typically achieved by soil vapor extraction systems.	Not applicable to inorganic constituents in solids and soils at the site.	NOT Retained
	Thermal	Vitrification		Solids or soils are electrically heated and fused into a stable, glass-like block.	Potentially implementable for small volumes of solids and soils.	Retained
		Desorption		Volatile compounds are separated or recovered from a solid or liquid matrix.	Not applicable to inorganic constituents in solids and soils at the site.	NOT Retained
	Biological	Enhanced Biodegradation		Nutrients are injected into soils to encourage native microorganisms to metabolize contaminants.	Not applicable for inorganic constituents.	NOT Retained
		Phytoremediation		Plants used to extract and concentrate organic constituents and metals/metalloids from soils.	Not applicable due to the presence of plant eating livestock and wildlife at the site.	NOT Retained

Technologies and/or process options screened out

FIGURE 4-3. EVALUATION OF PROCESS OPTIONS FOR EFFECTIVENESS, IMPLEMENTABILITY, AND RELATIVE COST

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	PROCESS OPTION	SCREENING RESULT
No Further Action	None	None		Retained
Institutional and Access Controls				
Institutional Controls	Government Controls	Closure Orders, Land-Use Controls, Grazing Controls		Retained
	Proprietary Controls	Deed Restrictions		Retained
	Enforcement and Permit Tools	Administrative Orders, Consent Decrees		Retained
	Information Devices	Signs, Information Programs		Retained
Access Controls	Physical Barriers	Fences, Gates		Retained
Containment				
Containment	Engineered Covers	Soil Cover		NOT Retained
		Tailings Cover		Retained
		Chert/Limestone Cover		Retained
		Dinwoody Cover		Retained
		Geosynthetic Cover		Retained
	Sediment Control Features	Dikes, Berms		Retained
		Detention Basins		Retained

Technologies and/or Process Options Screened Out

FIGURE 4-3. EVALUATION OF PROCESS OPTIONS FOR EFFECTIVENESS, IMPLEMENTABILITY, AND RELATIVE COST

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	PROCESS OPTION	SCREENING RESULT
Source Control and Routing				
Source Control, Flow Control and Routing	Surface Controls	Grading		Retained
		Erosion Control and Protection		Retained
		Vegetation		Retained
	Slope Stabilization	Slope Reduction		Retained
		Retaining Walls		Retained
	Diversion	Open Channels		Retained
		Closed Conduits		Retained
Removal and Disposal				
Removal and Disposal	Excavation	Removal of Solid Material		Retained
	Collection	Extraction Wells		Retained
	Solids Disposal	Onsite Disposal		Retained
		Onsite Consolidation		Retained
		Offsite Disposal		Retained
	Groundwater/Surface Water Disposal	Discharge to Onsite Treatment or Storage/Disposal Facility		Retained

Technologies and/or Process Options Screened Out

FIGURE 4-3. EVALUATION OF PROCESS OPTIONS FOR EFFECTIVENESS, IMPLEMENTABILITY, AND RELATIVE COST

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	PROCESS OPTION	SCREENING RESULT
Groundwater and Surface Water Treatment				
Ex-Situ Treatment	Physical	Separation	Gravity Separation	Retained
			Mechanical Separation	Retained
			Media Filtration	Retained
		Demineralization	Ultrafiltration/Reverse Osmosis	Retained
			Ion Exchange	NOT Retained
	Chemical	Adsorption	Activated Carbon	NOT Retained
			Metal Oxide	NOT Retained
		Chemical Precipitation		Retained
		Oxidation/Reduction		Retained
	Biological	Biodegradation		Retained
In-Situ Treatment	Biological	Biodegradation		Retained
Monitored Natural Attenuation (MNA)	In Conjunction with Above Remedial Technologies	None		Retained
Solids and Soils Treatment				
Ex-Situ Treatment	Physical	Stabilization/Fixation		Retained
	Chemical	Extraction		NOT Retained
In-Situ Treatment	Physical	Stabilization/Fixation		Retained
	Thermal	Vitrification		NOT Retained

Technologies and/or Process Options Screened Out

5.0 EVALUATION AND SELECTION OF REPRESENTATIVE TECHNOLOGIES

This section evaluates the remedial technology/process options retained after the initial screening in Section 4 for the Site media of concern for effectiveness, implementability, and relative cost. The goal of this final evaluation step is to further reduce the number of retained process options and to select representative technologies that ultimately will be used to develop remedial alternatives for the Site. Technologies/process options retained after this final screening step will be combined and assembled into a range of remedial alternatives in FSTM#2: Development, Screening, and Detailed Analysis of Alternatives.

The screening criteria used for this evaluation are as follows:

<u>Effectiveness</u> – Process options are evaluated on potential effectiveness in handling the estimated area or volume of solids and soils, groundwater, or surface water and on meeting the objectives identified in the RAOs. Process options are also evaluated relative to each other within the same technology type to reduce the number of process options for each technology.

<u>Implementability</u> – Technically implementable process options are evaluated for technical and administrative feasibility to eliminate those that are clearly ineffective, unworkable or not applicable to Site-specific conditions.

<u>Relative Cost</u> – Relative costs based on engineering judgment are ranked (i.e., low, moderate, high) for both capital and O&M. Costs for each process option are evaluated relative to other process options in the same technology type.

A summary of the detailed technology screening performed for Site media of concern in the FS (solids and soils, groundwater and surface water) is provided in Table 5-1 through Table 5-3.

5.1 Solids and Soils

Retained technologies and process options for solids and soils were further screened against the effectiveness, implementability, and cost criteria. The rationale for retaining or eliminating each technology/process option is presented below and summarized in Table 5-1.

5.1.1 No Action

No Further Action – The No Further Action option would entail no additional work at the Site. NTCRAs that have already been implemented would continue to be operated and maintained per existing Agreements. Pilot treatability studies would be terminated. As discussed in the RI/FS guidance (USEPA 1988), the No Action alternative is required by the NCP as a baseline for comparison with other remedial alternatives.

Effectiveness: Moderate. The 2013 NTCRA performed at the Pole Canyon ODA has covered 130 acres of overburden, preventing direct contact and erosion. This action has lowered the Site-wide average selenium concentration in surface soils. However, there would be no additional actions to limit exposures of human or ecological receptors to selenium or arsenic in overburden materials in ODAs.

Implementability: High. The No Further Action option is easily implementable because it requires no additional work at the Site. Operation and maintenance activities for the Pole Canyon ODA NTCRAs would continue.

Cost: No additional capital costs. No O&M costs (the costs for the Pole Canyon NTCRAs are included in the baseline alternative, i.e., zero for the detailed analysis).

Site-Specific Considerations: No further actions would be taken.

Applicability Within the Site: The No Further Action alternative is required by the NCP.

Decision Rationale: The No Further Action alternative is required by the NCP as a baseline against which other options are compared and is retained for the development of remedial alternatives.

5.1.2 Institutional Controls/Access Controls

Options that are applicable to solids and soils are institutional controls (land-use controls/grazing controls, administrative orders/consent decrees, and information programs) and access controls (fences/gates). Evaluation of each of these process options for effectiveness, implementability, and cost is provided below.

Land-Use Controls/Grazing Controls – Land-use controls are legal and administrative actions to limit the potential exposure to selenium and other COCs under both current and future land-use scenarios. Because ODAs are located on public land managed by the Caribou-Targhee National Forest, land-use controls such as closure orders could be used by the Forest Service to prevent access to the Site or prevent activities that could compromise the integrity of remedial actions. Grazing controls could include guidelines for the duration of grazing, the type of livestock allowed to graze on the area, timing of grazing, or closure of grazing allotments to allow for covered areas to be revegetated.

Effectiveness: High. Land-use controls could be used to limit access and prevent direct human and/or wildlife exposure to elevated selenium and arsenic concentrations in soil, associated vegetation, and overburden material on the Site while the cover vegetation matures.

Implementability: High. These types of institutional controls are easy to implement because overburden areas at the Smoky Canyon Mine are on public lands that are managed by the Forest Service.

Cost: Low capital costs. Low O&M costs.

Site-Specific Considerations: Land-use controls and grazing controls are effective in limiting access and preventing activities that could compromise the integrity of remedial actions.

Applicability Within the Site: Land-use controls and grazing controls are applicable for areas of the Site on public lands.

Decision Rationale: Land-use controls and grazing controls are effective in limiting access and preventing exposure to selenium and arsenic in overburden materials. Land-use controls and grazing controls are a typical component of an overall Site remedy and are retained for the development of alternatives.

Administrative Orders/Consent Decrees – Administrative orders and consent decrees could be implemented to limit certain activities or require the performance of specific activities such as monitoring or reporting on effectiveness of remedial actions.

Effectiveness: High. Administrative orders and consent decrees are legally binding and could be enforced at a relatively low cost. They are effective in requiring the performance of monitoring or reporting on the effectiveness of a remedy.

Implementability: High. Enforcement tools such as administrative orders and consent decrees could be issued unilaterally or negotiated by the Agencies participating in the RI/FS process at the mine and are easy to implement.

Cost: Low capital costs. Low O&M costs.

Site-Specific Considerations: Administrative orders and consent decrees are effective in requiring the performance of monitoring or reporting on the effectiveness of a remedy.

Applicability Within the Site: Administrative orders and consent decrees are applicable for evaluation of the effectiveness of a remedy such as a cover system.

Decision Rationale: Administrative orders and consent decrees are effective in requiring effectiveness monitoring and reporting and are retained for the development of remedial alternatives.

Information Programs – Information programs could be used to convey information on land use or land-use restrictions as a result of remedial actions and to notify the public that covered contamination remains at the Site. For example, during the period that cover systems vegetation is maturing, it would be appropriate to inform the public that access is restricted until certain components of the remedy are complete.

Effectiveness: High. Information programs are effective in reducing the likelihood of public exposure to selenium and arsenic in overburden solids and soils.

Implementability: High. Information programs are easy to develop and implement for public awareness.

Cost: Low capital costs. Low O&M costs.

Site-Specific Considerations: Information programs are effective in restricting activities that could compromise remedial actions and in notifying the public that covered contamination remains at the Site.

Applicability Within the Site: Information programs are applicable for areas of the Site on public lands.

Decision Rationale: Institutional controls such as information programs are a typical component of an overall Site remedy. Information programs are effective and are retained for use with other remedial technologies.

Fences/Gates – Fences and gates are physical barriers that could be used to limit access and prevent direct exposure to contaminants in source areas on the Site.

Effectiveness: Moderate. Fencing is effective at limiting access to elevated concentrations of selenium and arsenic in soil and vegetation on ODAs at the Site.

Implementability: High. The materials and equipment are readily available and building a fence to restrict access to contaminated soils and vegetation would be easy to implement.

Cost: Low capital costs. Low O&M costs.

Site-Specific Considerations: Fencing is effective in preventing large animal exposure to selenium in soil and vegetation on ODAs but would not prevent access to smaller animals or birds.

Applicability Within the Site: Fencing is potentially applicable to relatively small areas that have unacceptable risks (for example soil at seeps or ponds).

Decision Rationale: Fencing is effective at limiting large animal access and preventing direct exposure to selenium and arsenic in soils and overburden material on the Site. Fencing is retained for use with other remedial technologies.

5.1.3 Containment/Engineered Covers

Containment options that are applicable to solids and soils include various types of engineered cover systems constructed to provide a stable, physical barrier to prevent direct contact with overburden. Evaluation of this type of cover system for effectiveness, implementability, and cost is provided below.

Chert/Limestone Cover – Chert/Limestone could be used as a physical barrier layer, a conveyance layer, or a capillary break layer of a multi-layer cover system to provide an additional thickness of non-seleniferous material overlying the overburden within the cover profile. Chert/Limestone is effective in preventing direct contact with overburden material and reducing levels of selenium in vegetation growing on the cover.

Effectiveness: High. Chert/Limestone is proven effective in preventing vegetation from rooting.

Implementability: High. Chert/Limestone covers are implementable and are composed of proven, effective materials that have already been used extensively at the Site for post-mining reclamation and in the 2013 Pole Canyon NTCRA.

Cost: Moderate capital costs. Low O&M costs.

Site-Specific Considerations: Chert/Limestone is readily available in the Rex Chert Member at the Site and is proven effective in preventing vegetation from rooting.

Applicability Within the Site: Chert/Limestone is applicable as a capillary break layer and/or a barrier layer for vegetation uptake of COCs in different cover types.

Decision Rationale: Chert/Limestone is effective as a barrier layer or a water conveyance layer and is typically combined with other materials for an effective system and is retained for the development of remedial alternatives.

Dinwoody Cover – Dinwoody material could be used as a single layer or as a component in combination with other materials in a multi-layer system (i.e., Enhanced Dinwoody Cover currently in use at Panel F) in a physical barrier cover system to prevent direct contact with overburden and provide a growth medium for vegetation.

Effectiveness: High. Dinwoody Formation material is proven effective in preventing direct contact with overburden material.

Implementability: High. The Dinwoody cover is implementable and is composed of proven, effective materials that have already been used extensively at the Site for post-mining reclamation and in the 2013 Pole Canyon NTCRA.

Cost: Moderate capital costs. Low O&M costs.

Site-Specific Considerations: Dinwoody Formation material is available at the Site and is proven effective in preventing contact with overburden material.

Applicability Within the Site: Dinwoody material is applicable as a soil layer with a low saturated hydraulic conductivity and a high moisture storage capacity that would support vegetation growth as part of a barrier cover system.

Decision Rationale: Dinwoody material is effective in preventing direct contact with overburden, is present at the Site, and can support vegetation growth. Dinwoody material could be combined with other cover layers and is retained for the development of remedial alternatives.

5.1.4 Source Control and Routing

Source control and routing process options are applicable for solids and soils but may also provide benefits for groundwater and surface water by reducing or eliminating releases of selenium from soils and overburden into groundwater or surface water. Source control and routing include surface controls (grading, erosion control, and vegetation) and slope stabilization (slope reduction and retaining walls). Evaluation of each of these options for effectiveness, implementability, and cost is provided below.

Surface Controls (Grading and Erosion Control) – Land surface alterations associated with surface controls are blended with surrounding undisturbed ground to provide a smooth transition in topography. Soil grading could be used to manage surface water infiltration and runoff. Erosion protection consists of the use of erosion-resistant materials such as riprap, vegetation, and geosynthetic fabrics to reduce or eliminate erosion of solids and soils by storm water runoff. Erosion control fabric could also be used to protect seedlings during germination.

Effectiveness: Moderate. Grading and erosion control are not effective in preventing access to contaminated solids and soils associated with overburden materials, but they are effective in reducing releases of selenium and arsenic from overburden into groundwater and surface water.

Implementability: High. Grading and erosion control are implementable using conventional construction techniques and could be used during ODA cover construction.

Cost: Low to moderate capital costs (depends on scale of action). Low O&M costs.

Site-Specific Considerations: Grading could be implemented to increase or direct water runoff and as part of installation of a cover. Erosion control is effective in reducing the migration of solids from covered or uncovered areas.

Applicability Within the Site: Grading is applicable for eliminating areas where pooling of water occurs and to manage surface water infiltration. Erosion control is applicable for use during and after cover construction to reduce transport of solids by storm water runoff.

Decision Rationale: Grading and erosion controls are retained for use in cover construction due to their benefit during construction and on covered/uncovered areas in reducing transport of solids in storm water.

Surface Controls (Vegetation) – Establishing a vegetative cover is a standard surface reclamation technology that could be used for ODAs and is a component of an overall Site remedy.

Effectiveness: Moderate. In addition to stabilizing surface materials by reducing erosion potential, vegetation is effective in increasing evapotranspiration at the surface and reducing water infiltration into overburden and subsequent release of selenium and arsenic. Planting of native species that have low affinity for selenium uptake may be effective in reducing potential risks to ecological receptors. Vegetation also improves aesthetics. Previous response actions at the Pole Canyon ODA have demonstrated the effectiveness of revegetation measures in conjunction with containment/covers.

Implementability: High. Vegetation is implementable in conjunction with surface controls such as grading and erosion control and with containment options.

Cost: Moderate capital costs. Low O&M costs.

Site-Specific Considerations: Vegetation is effective in stabilizing surface materials, reducing erosion potential, and increasing evapotranspiration. Species management (i.e., planting native species and eliminating selenium-accumulating species) could also reduce selenium uptake.

Applicability Within the Site: Vegetation is applicable for use on covered and uncovered ODAs at the Site.

Decision Rationale: Vegetation is an effective element of cover systems and could be used to stabilize surfaces and reduce selenium uptake on covered and uncovered areas and is retained for use with other technologies.

Slope Stabilization (Slope Reduction and Retaining Walls) – Slope stabilization techniques such as slope reduction and retaining walls could be used to reduce erosion and sediment transport. Reducing the grade of slopes slows storm water runoff which limits erosion, promotes vegetation growth, and reduces the potential for slope failure. Retaining walls could be used to stabilize steep slopes by reducing the effective slope of an earthen surface such as an ODA.

Effectiveness: Moderate. Slope reduction and retaining walls are moderately effective in stabilizing slopes. Both process options were used as part of the 2013 NTCRA at the Pole Canyon ODA and could be used in cover installation at other ODAs (to be determined during remedial design).

Implementability: High. Slope stabilization is implementable using conventional construction techniques and could be used during ODA cover construction.

Cost: Low to moderate capital costs. Low O&M costs.

Site-Specific Considerations: Slope stabilization was used in the 2013 Pole Canyon NTCRA and is readily implementable using conventional construction techniques.

Applicability Within the Site: Slope reduction and retaining walls are applicable for stabilization of slopes during construction of cover systems on ODAs.

Decision Rationale: Slope stabilization is retained for use in conjunction with cover construction in the development of remedial alternatives for the Site.

5.1.5 Removal and Disposal

Removal and disposal technologies/process options applicable to solids and soils include excavation and disposal (onsite consolidation/disposal or offsite disposal). Evaluation of each of these options for effectiveness, implementability, and cost is provided below.

Excavation – Conventional excavation could be used for removal of overburden solids/waste rock materials and soils/sediments from ODAs or detention basins, or for contouring an area prior to construction of a cover system. The removed materials could be further treated, consolidated, placed under a cap, or used in the construction of a cover system.

> Effectiveness: High. Excavation is effective for removing small volumes of materials such as sediment in seep areas or ponds and treatment residuals.
>
> Implementability: High. Conventional excavation could be easily implemented for excavation and consolidation of solid materials or excavation and reuse of soils as part of the remedial action.
>
> Cost: Low to high capital costs. Low to moderate O&M costs associated with re-establishment of vegetation and prevention of erosion.
>
> Site-Specific Considerations: Conventional excavation of overburden solids/soils is not effective or implementable for pit backfill or overburden material in external ODAs. Excavation is effective and implementable for small volumes of materials such as sediment in seep areas or ponds and in-situ treatment residuals.
>
> Applicability Within the Site: Excavation may be applicable for small volumes of materials.
>
> Decision Rationale: Excavation is not applicable for overburden solids and soils and is not retained. Excavation is retained for small volumes of sediment and/or in-situ treatment residuals.

Onsite Consolidation/Disposal – Onsite consolidation of overburden material by backfilling pits and reclaiming slopes could be beneficial to reduce the overall footprint of waste materials. Onsite consolidation of small volumes of nonhazardous treatment residuals from the treatment systems (e.g., sludge from the fluidized bed bioreactor system or spent media from a passive treatment system) in backfilled pits could minimize leaching of selenium and arsenic from external ODAs.

> Effectiveness: High. Complete source removal/disposal is not effective for pit backfill and external ODAs due to the large material volume (millions to tens of millions of cubic yards) and the fact that the resultant disposal area would have similar or worse environmental conditions as the current pit backfill and ODAs. Residual sediment remaining in seep

areas or in storm water/seep detention ponds could be removed and consolidated onsite. Similarly, residual solid materials generated by water treatment, could be consolidated onsite if their chemical properties are suitable. Disposal areas would likely be covered.

Implementability: High. Complete source removal/disposal is not implementable for pit backfill and external ODAs because of the large material volume and the lack of a suitable location for disposal. Onsite consolidation/disposal is implementable for small volumes of material such as seep or pond sediment and/or treatment residuals.

Cost: Low capital costs (small volumes of material). Low O&M costs.

Site-Specific Considerations: Onsite consolidation/disposal of overburden solids and soils is readily implementable and effective using conventional construction techniques. Onsite consolidation/disposal is effective for small volumes of materials such as sediment in seep areas or ponds and treatment residuals. Onsite consolidation/disposal is potentially implementable, as long as the disposal setting is suitable to prevent remobilization of selenium and arsenic into the environment.

Applicability Within the Site: Onsite consolidation/disposal is not applicable because existing mine pits have already been backfilled and overburden material has already been consolidated into ODAs. However, onsite consolidation/disposal may be applicable for small volumes of materials such as from sedimentation basins or seep areas.

Decision Rationale: Onsite consolidation/disposal is not applicable for the large material volumes of overburden solids and soils and is not retained. Onsite consolidation/disposal is retained for small volumes of material such as seep or pond sediment and/or treatment residuals.

Offsite Disposal – Excavated solid media could be disposed of offsite. Offsite disposal requires excavating the impacted solid media and transporting it to an appropriate disposal facility. Impacted materials (soils/solids or water treatment residuals that exceed RCRA toxicity criteria would require disposal in a hazardous waste landfill).

Effectiveness: High. Offsite disposal would reduce the volume of waste material and is considered to be a suitable process option for all solid media.

Implementability: Low to High. Offsite disposal is not implementable for large volumes of overburden solids/soils at the Site. However, offsite disposal is implementable for small volumes of materials (such as residuals from water treatment systems).

Cost: High capital costs. No O&M costs.

Site-Specific Considerations: Offsite disposal is not implementable for the large volumes of overburden solids/soils at the Site. However, offsite disposal is effective and implementable for small volumes of materials such as treatment residuals.

Applicability Within the Site: Offsite disposal is not applicable because the overburden at the Site has already been consolidated into ODAs onsite. However, offsite disposal may be applicable for small volumes of material.

Decision Rationale: Offsite disposal is not applicable for overburden solids/soils and is not retained. Offsite disposal is retained for small volumes of materials such as treatment residuals.

5.1.6 Ex-Situ Treatment

Ex-situ treatment options applicable to solids and soils are limited to stabilization/fixation. Evaluation for effectiveness, implementability, and cost is provided below.

Stabilization/Fixation – Ex-situ stabilization generally involves excavation of the solids, mechanical mixing of the solids with stabilizing agents, curing of the mass for optimal reduction in leachability, followed by onsite or offsite disposal. A variety of stabilization agents are available and could be used, including cement, fly ash, silica, bentonite, and various polymers.

Effectiveness: Low. Although stabilization/fixation has been shown to be effective for reducing the leachability of heavy metals, the process is not effective for immobilizing the relatively low concentrations of selenium and arsenic in overburden solids and soils.

Implementability: Low. The implementability of stabilization/fixation is low due to the large volume of overburden solids and soils at the Site. The process is better suited to coarse sands and gravels than to the fine silts and clays that characterize waste shales in the overburden material.

Cost: Very high capital costs. Low O&M costs.

Site-Specific Considerations: Ex-situ stabilization/fixation is not effective or implementable for immobilizing contaminants in overburden solids and soils.

Applicability Within the Site: Ex-situ stabilization/fixation is not applicable for treatment of the large volumes of overburden solids and soils at the Site.

Decision Rationale: Ex-situ stabilization/fixation is not retained because it is not effective or implementable for conditions found at the Site.

5.1.7 In-Situ Treatment

In-situ treatment technologies/process options applicable to solids and soils is limited to stabilization/fixation. Evaluation for effectiveness, implementability, and cost is provided below.

Stabilization/Fixation – In-situ stabilization/fixation is performed by directly injecting stabilizing agents such as cement, fly ash, silica, bentonite, or various polymers into the soil using rotary injection augers, jet grouting, and/or pressure grouting techniques.

> Effectiveness: Low. Although stabilization/fixation has been shown to be effective for reducing the leachability of heavy metals, the process is not effective for immobilizing the relatively low concentrations of selenium and arsenic in overburden.
>
> Implementability: Low. As with ex-situ treatment, the implementability of in-situ stabilization/fixation is low due to the large volume and fine grain size of the overburden solids at the Site.
>
> Cost: High capital costs. Low O&M costs.
>
> Site-Specific Considerations: In-situ stabilization/fixation is not effective or implementable for immobilizing contaminants in overburden solids.
>
> Applicability Within the Site: In-situ stabilization/fixation is not applicable for treatment of the large volumes of overburden solids at the Site.
>
> Decision Rationale: In-situ stabilization/fixation is not retained because it is not effective or implementable for conditions found at the Site.

5.2 Groundwater

Retained technologies and process options for groundwater are further screened against the effectiveness, implementability, and cost criteria (Table 5-2).

5.2.1 No Action

No Further Action – The No Further Action alternative would entail no additional work at the Site. NTCRAs that have already been implemented would continue. Pilot treatability studies would be terminated. As discussed in the RI/FS guidance (USEPA 1988), the No Action alternative is required by the NCP as a baseline for comparison with other remedial technologies.

Effectiveness: Moderate. The 2006 and 2013 NTCRAs have resulted in a significant reduction in releases of selenium to groundwater from the Pole Canyon ODA. This is expected to improve groundwater quality over time. However, there would be no additional actions to reduce infiltration into overburden in ODAs at the Site.

Implementability: High. The No Further Action alternative is easily implementable because it requires no additional work at the Site. Operation and maintenance activities for the Pole Canyon ODA NTCRAs would continue.

Cost: No additional capital costs. No O&M costs (the costs for the Pole Canyon NTCRAs are included in the baseline alternative, i.e., zero for the detailed analysis).

Site-Specific Considerations: No further actions would be taken.

Applicability Within the Site: The No Further Action alternative is required by the NCP.

Decision Rationale: The No Further Action alternative is required by the NCP as a baseline against which other options are compared and is retained for the development of remedial alternatives.

5.2.2 Institutional Controls

Several institutional controls (administrative orders/consent decrees and deed restrictions) are applicable for groundwater. Evaluation of each of these process options for effectiveness, implementability, and cost is provided below.

Administrative Orders/Consent Decrees – Administrative orders/consent decrees are enforcement tools that could require monitoring and reporting of the performance and effectiveness of a remedy. Institutional controls are typically a component of an overall Site remedy.

Effectiveness: High. Administrative orders and consent decrees are legally binding. Enforcement tools could be effective in requiring groundwater monitoring to evaluate the effectiveness of containment/source control remedies at the Site.

Implementability: High. Enforcement tools such as administrative orders and consent decrees could be issued unilaterally or negotiated by the Agencies participating in the RI/FS process at the mine and are easy to implement.

Cost: Low capital costs. Low O&M costs.

Site-Specific Considerations: Enforcement tools could be effective in requiring groundwater monitoring to evaluate the effectiveness of containment/source control remedies at the Site.

Applicability Within the Site: Administrative orders and consent decrees are applicable for compliance monitoring at the Site.

Decision Rationale: Administrative orders/consent decrees are effective in requiring effectiveness monitoring and reporting and are retained for the development of remedial alternatives.

Deed Restrictions – Deed restrictions could be used to prevent the use of groundwater with arsenic or selenium concentrations above their respective MCLs as a domestic water supply. Proprietary controls such as deed restrictions are typically a component of an overall Site remedy.

Effectiveness: Moderate. Deed restrictions are effective in preventing groundwater extraction and use as a drinking source on private land. They do not address the sources of selenium to groundwater but would be effective as part of an overall remedy while remedial components are taking effect and arsenic and selenium concentrations remain above MCLs in groundwater.

Implementability: High. Because Simplot owns the land in Sage Valley, implementation of deed restrictions to prevent the use of groundwater as domestic water supply would be straight forward.

Cost: Low capital costs. Low O&M costs. Deed restrictions could be implementable for a relatively low cost.

Site-Specific Considerations: Deed restrictions could be implemented to prevent the use of groundwater with arsenic or selenium concentrations above MCLs as a domestic water supply.

Applicability Within the Site: Deed restrictions are applicable on Simplot-owned land in Sage Valley.

Decision Rationale: Deed restrictions could be effective in protecting people until the remedy becomes effective and are retained for the development of remedial alternatives.

5.2.3 Containment/Engineered Covers

Containment options that are applicable to groundwater include various types of engineered cover systems (tailings cover, chert/limestone cover, Dinwoody cover, and geosynthetic cover) to reduce infiltration into overburden and subsequent release and transport of selenium to groundwater. Evaluation of each of the material options for cover systems for effectiveness, implementability, and cost is provided below. Ultimately the retained materials will be assembled into appropriate combinations to provide distinct cover types for remedial alternatives in the detailed analysis.

Tailings Cover – Tailings material, which is readily available at the Site, has relatively low hydraulic conductivity and could be used in a cover to reduce infiltration into ODAs.

Effectiveness: Moderate. Tailings material has the potential to be effective for use in cover systems due to its low hydraulic conductivity which could reduce infiltration into underlying overburden materials. As shown in the Tailings Revegetation Field-Scale Pilot Study (Formation 2013c), vegetation can establish and grow on tailings material, with or without amendments, and selenium uptake into plants is relatively low.

Implementability: Low. Tailings material is potentially implementable for use in ODA cover systems. Because the material could be highly-erodible on an ODA slope, tailings would not be suitable as a surface material. Potential difficulties in placing the material on ODA slopes would also make use of tailings as a subsurface layer in a cover system problematic.

Cost: Moderate capital costs. Moderate O&M costs.

Site-Specific Considerations: Tailings material is readily available at the Area B tailings impoundments.

Applicability Within the Site: Tailings material is potentially applicable for use as a layer in multi-layer cover systems to reduce infiltration into ODAs.

Decision Rationale: Because tailings material could be highly erodible on an ODA slope, it is not suitable as a surface material but could be used as a subsurface layer (though it would be difficult to place on a slope during cover construction). It could also be difficult to construct as a subsurface layer in a cover system. Erodibility on slopes and performance make tailings less desirable than other materials that are available at the Site. Therefore, a tailings cover is eliminated from further consideration in the development of remedial alternatives.

Chert/Limestone Cover – Chert/Limestone could be used as a physical barrier layer, a water conveyance layer, or a capillary break layer of a multi-layer cover system to provide an additional thickness of non-seleniferous material above the overburden within the cover profile.

Effectiveness: High. Chert/Limestone is proven effective in multi-layer cover systems. It does little to reduce infiltration but can provide an important function, such as protecting other layers or conveying water within the cover.

Implementability: High. Chert/Limestone covers are implementable and are composed of proven, effective materials that have already been used extensively at the Site for post-mining reclamation and in the 2013 Pole Canyon NTCRA.

Cost: Moderate capital costs. Low O&M costs.

Site-Specific Considerations: Chert/Limestone is readily available in the Rex Chert Member at the Site and is proven effective in preventing vegetation from rooting.

Applicability Within the Site: Chert/Limestone is applicable for use in cover systems as a capillary break layer and/or a barrier layer in different cover types.

Decision Rationale: Chert/Limestone is effective as a barrier layer or a water conveyance layer and is typically combined with other materials for an effective system and is retained for the development of remedial alternatives.

Dinwoody Cover – Dinwoody material could be used in an ODA cover system and is effective in reducing infiltration. One option is a water balance cover that relies on temporary storage of snow melt and rain water in soil near the surface coupled with removal of stored water by evaporation and transpiration. Water balance (or "ET covers") consist of a monolithic layer of Dinwoody material or other soil. Other configurations may be more effective.

Effectiveness: High. Dinwoody Formation material is proven effective in reducing infiltration of water (and thereby reducing the subsequent release of selenium to groundwater). Cover configurations (i.e., thickness and combination with Chert/Limestone or other constituents) will be evaluated in the initial FSTM#2 screening step to identify cover systems to be evaluated in the detailed analysis.

Implementability: High. The Dinwoody cover is implementable and is composed of proven, effective materials that have already been used extensively at the Site for post-mining reclamation and in the 2013 Pole Canyon NTCRA.

Cost: Moderate capital costs. Low O&M costs.

Site-Specific Considerations: Dinwoody Formation material is available at the Site and is proven effective in reducing infiltration and the mobility of selenium. The volume and suitability of the Dinwoody on Site still needs to be evaluated.

Applicability Within the Site: Dinwoody material is applicable as a soil layer with a low saturated hydraulic conductivity to reduce infiltration and a high moisture storage capacity that would support vegetation growth as part of a multi-layer cover system.

Decision Rationale: Dinwoody material is effective in reducing infiltration to overburden and is present at the Site. Dinwoody material could be combined with other cover layers and is retained for the development of remedial alternatives.

Geosynthetic Cover – Geosynthetic covers (i.e., with a GM liner, a GCL, or equivalent) consist of multiple layers that could be used to reduce infiltration into the overburden material. A low permeability geosynthetic cover would require an overlying natural or geosynthetic drainage layer and a relatively flat closure slope for stability.

Effectiveness: High. Geosynthetic covers are effective in reducing infiltration into the overburden material and could be part of an overall Site remedy. The GCL technology has been implemented in southeast Idaho, notably at South Maybe Canyon Mine (a CERCLA action on a cross-valley fill ODA) and at the Blackfoot Bridge Mine (as part of active mining).

Implementability: Moderate. Geosynthetic covers are implementable using conventional construction techniques. The closure slope generally needs to be flatter than 3:1 to achieve stability of the cover over the geosynthetic materials. For side slopes of 3:1, additional anchoring of the geosynthetic is required and angular gravel or rock is required above a geotextile for stability of this layer.

Cost: High capital costs. High O&M costs.

Site-Specific Considerations: Geosynthetic covers are effective in limiting infiltration and reducing the mobility of selenium but are more difficult to implement than other types of covers because of problems related to tearing the membrane.

Applicability Within the Site: Geosynthetic covers are applicable as a low permeability layer of a multi-layer cover system.

Decision Rationale: Geosynthetic cover layers are effective in reducing infiltration into the ODAs but have lower implementability and higher capital and O&M costs relative to other types of cover layers. Geosynthetic covers are retained for the development of alternatives.

5.2.4 Source Control and Routing

Source control and routing process options for groundwater are limited to diversion (open/closed channels). This option is evaluated for effectiveness, implementability, and cost.

Diversion (Open/Closed Channels) – Diversion channels could be used to route groundwater that discharges at the springs complex to a treatment facility and are likely to be a critical component of an overall Site remedy.

Effectiveness: High. Diversion channels are effective in routing groundwater to a treatment facility at the Site.

Implementability: High. This process is being implemented in the Hoopes Water Treatment Plant (WTP) Pilot Study and additional conveyance systems may be installed to maintain the required influent flow and quality to any treatment system that is part of the final remedy.

Cost: Low capital costs. Low O&M costs.

Site-Specific Considerations: Open or closed channels are effective means of conveying groundwater that discharges to the surface at springs to a treatment facility at the Site.

Applicability Within the Site: Diversion channels are applicable for conveying groundwater to a treatment facility.

Decision Rationale: Diversion channels are effective in conveying groundwater and may be used as part of an overall Site remedy and are retained.

5.2.5 Removal and Disposal

Removal and disposal process options applicable to groundwater are limited to extraction wells for removal and groundwater disposal to a treatment system. Evaluation of these options for effectiveness, implementability, and cost is provided below.

Groundwater Removal (Extraction Wells) – Extraction wells could be used to capture groundwater and control gradients and flow direction. Multiple extraction wells could be installed along preferential pathways and along the West Sage Valley Branch Fault. Extracted groundwater could be routed to an onsite treatment facility.

Effectiveness: Low. The effectiveness of groundwater extraction wells is low because groundwater flow within the Wells Formation is influenced by preferential flow paths and placement of a Wells Formation well within zones of high transmissivity and high concentrations of COCs would be difficult, as demonstrated during well installation for the RI (Formation 2014c).

Implementability: High. Drilling and installation of groundwater extraction wells is easy to implement.

Cost: High capital costs. Low O&M costs.

Site-Specific Considerations: Use of extraction wells upgradient of Hoopes Springs is unlikely to be effective due to known hydrogeologic complexities. Groundwater reports to the surface at Hoopes Spring and South Fork Sage Creek Springs and could be collected for treatment there if necessary.

Applicability Within the Site: Extraction wells are not applicable for groundwater at the Site.

Decision Rationale: Hoopes Spring acts as a regional groundwater discharge feature and effectively captures the migration of COCs within Wells Formation groundwater. Groundwater reports to the surface without the need for extraction wells. Removal via extraction wells is not retained for the development of remedial alternatives.

Groundwater Disposal (Discharge to Onsite or Other Storage/Disposal Treatment Facility) – Groundwater collected at the springs complex could be routed to an onsite treatment or other storage/disposal facility using piping and pumps. Groundwater disposal could be applied with ex-situ treatment as part of an overall Site remedy.

Effectiveness: High. Conveyance of impacted groundwater discharged at the springs complex to the Hoopes WTP Pilot Study is proven effective in reducing the concentrations of selenium and arsenic in groundwater and in reducing the selenium mass load discharged to surface water downstream in Sage Creek.

Implementability: High. Piping and pumps from the pilot study are currently in place and would be easy to implement.

Cost: Low capital costs. Low O&M costs.

Site-Specific Considerations: Discharge of groundwater from Hoopes Spring and South Fork Sage Creek springs to an onsite treatment or other storage/disposal facility would require a conveyance system. Piping and pumps are currently in place and effectively convey groundwater to the Hoopes WTP Pilot Study.

Applicability Within the Site: Groundwater conveyance/discharge to an onsite or other storage/disposal treatment facility is applicable in areas where MCLs are exceeded in alluvial or Wells Formation groundwater.

Decision Rationale: Discharge of extracted groundwater to an onsite treatment or other storage/disposal facility is effective and is retained for the development of remedial alternatives.

5.2.6 Ex-Situ Treatment

Ex-situ treatment technologies/process options applicable to groundwater include a variety of physical (gravity/mechanical separation, media filtration, and ultrafiltration/reverse osmosis), chemical (chemical precipitation and oxidation/reduction), and biological (biodegradation) technologies. Evaluation of each of these process options for effectiveness, implementability, and cost is provided below.

Gravity/Mechanical Separation – Gravity or mechanical methods could be used to separate suspended solids from groundwater. Gravity separation involves settling of suspended solids in ponds, basins, or tanks, using baffles or other devices and typically results in sludge with a solids content of 30% to 40% by weight. Mechanical separation involves using devices such as belt presses, filter presses, or vacuum filtration units to remove suspended solids and typically results in a sludge with up to 70% solids.

Effectiveness: Low by itself, High in combination with other technologies. Selenium is in the dissolved form in groundwater and therefore gravity/mechanical separation would not be effective as a stand-alone technology. However, it could be used as part of a treatment system that converts selenium to the solid phase.

Implementability: High. The implementability of gravity/mechanical separation as part of an overall treatment system is high.

Cost: Moderate capital costs. Moderate O&M costs.

Site-Specific Considerations: Gravity/mechanical separation is used to settle waste streams in the Hoopes WTP Pilot Study and effectively removes reduced, elemental selenium from groundwater at the Site.

Applicability Within the Site: Gravity/mechanical separation is applicable for dewatering waste streams from other treatment technologies.

Decision Rationale: Gravity/mechanical separation is retained for use with other treatment technologies and is effective in removing reduced, elemental selenium from groundwater.

Media Filtration – Media filtration is a separation process that uses granular material through which influent water flows to filter suspended solids. Media filtration (i.e., sand filtration) is not a stand-alone treatment for groundwater but could be used to trap suspended solids on top of and within the sand filter bed while allowing effluent to flow through it.

Effectiveness: High. Media filtration is effective when used in conjunction with other treatment technologies.

Implementability: High. The implementability of media filtration as part of an overall treatment system is high.

Cost: Moderate capital costs. Moderate O&M costs.

Site-Specific Considerations: Media filtration (typically using sand) is proven effective for removing suspended solids and trapping the particles on/in a filter bed at the Hoopes WTP Pilot Study.

Applicability Within the Site: Media filtration is applicable as a component of an overall treatment system for groundwater at the Site.

Decision Rationale: Media filtration is retained for use with other treatment technologies and is proven effective for removing suspended solids in groundwater.

Ultrafiltration/Reverse Osmosis – Ultrafiltration/reverse osmosis is a membrane-filtration technology that could be used to separate and concentrate selenium in groundwater. The pore size of the ultrafiltration membrane is slightly larger than the pore size of the reverse osmosis membrane. This technology would require further treatment to remove selenium and arsenic from the concentrate stream prior to discharge.

Effectiveness: High. Ultrafiltration/reverse osmosis is effective for separating dissolved selenium in groundwater load using a semipermeable membrane and has been tested at the Site for the Hoopes WTP Pilot Study.

Implementability: High. The implementability of ultrafiltration/reverse osmosis, as part of an overall treatment system, is high.

Cost: High capital costs. High O&M costs. Capital costs are high for construction of the treatment system. O&M costs are high due to the high electrical power requirements.

Site-Specific Considerations: Ultrafiltration/reverse osmosis (UF/RO) technologies are proven effective for producing concentrated selenium water for additional treatment and have been tested at the Hoopes WTP Pilot Study.

Applicability Within the Site: Ultrafiltration/reverse osmosis is applicable as a component of an overall treatment system for groundwater that discharges at Hoopes Spring.

Decision Rationale: Ultrafiltration/reverse osmosis technologies are proven effective for producing concentrated selenium water for additional treatment and have been tested at the Hoopes WTP Pilot Study at the Site. This technology could be combined with other technologies for improved selenium removal efficiency and is retained for development of alternatives for groundwater.

Chemical Precipitation – Chemical precipitation could be used to precipitate dissolved ions/salts in the form of insoluble salts by adding chemicals to reach chemical saturation and/or varying the pH. The insoluble salts may be removed from the groundwater by sedimentation, coagulation, and/or flocculation.

Effectiveness: Low. Chemical precipitation is not effective for oxidized forms of selenium (selenite) and would require a separate process to electrochemically reduce oxidized forms of selenium to reduced forms (selenite).

Implementability: High. The implementability of chemical precipitation is high because it is a common treatment process that is straightforward to implement for groundwater.

Cost: Moderate capital costs. High O&M costs.

Site-Specific Considerations: Chemical precipitation is more effective for reduced forms of selenium. Because selenium at the Site generally occurs in oxidized forms, additional steps may be required for removal efficiency.

Applicability Within the Site: Chemical precipitation could be applicable for groundwater treatment but would require additional treatment trains.

Decision Rationale: Chemical precipitation is not retained due to low effectiveness for oxidized selenium.

Oxidation/Reduction – The chemical oxidation/reduction process uses agents such as oxidation, chlorination, hydrogen peroxide, and ultraviolet light to react with and oxidize contaminants in groundwater. Oxidation/reduction reactions may improve the separation characteristics for removal of selenium in groundwater if used in conjunction with other treatment technologies.

Effectiveness: Low. Oxidation/reduction is not effective for removal of oxidized selenium.

Implementability: High. Oxidation/reduction is implementable for groundwater treatment.

Cost: Moderate capital costs. High O&M costs.

Site-Specific Considerations: Oxidation/reduction is more effective for reduced forms of selenium. Because selenium at the Site generally occurs in oxidized forms, additional steps may be required for removal efficiency.

Applicability Within the Site: Oxidation/reduction could be applicable for groundwater treatment but would require additional treatment trains.

Decision Rationale: Oxidation/reduction is not retained due to low effectiveness for oxidized selenium.

Ex-Situ Biological Treatment (Biodegradation) – Biological treatment could be used to degrade or reduce contaminants with microorganisms. Groundwater could be extracted and pumped to a process location (e.g., wetlands, anaerobic bioreactor, or fluidized bed bioreactor) for treatment. Metals and other inorganic contaminants could be removed from the water using anaerobic bacteria that decrease the solubility via biological processes and then precipitated or absorbed by the media in the wetlands or bioreactor.

Effectiveness: High. Biodegradation is effective as part of an active water treatment plant such as an anaerobic fluidized bed bioreactor.

Implementability: High. Ex-situ biodegradation is implementable. The Hoopes WTP Pilot Study started with one skid and has been sized up to a full-scale system.

Cost: Moderate capital costs. Moderate O&M costs.

Site-Specific Considerations: Ex-situ biological treatment is proven effective for removing selenium at the Hoopes WTP Pilot Study fluidized bed bioreactor (FBR). Microbial reduction of selenate and selenite to elemental selenium allows for easier removal of selenium by other technologies in the treatment train.

Applicability Within the Site: Ex-situ biological treatment is applicable for groundwater that discharges at Hoopes Spring and South Fork Sage Creek Springs.

Decision Rationale: Ex-situ biological treatment is retained because the process is effective for reducing selenium concentrations in groundwater and has been tested at the Site. As determined by design and operations testing, other process options (listed above) may be required to support an ex-situ biological treatment system.

5.2.7 In-Situ Treatment

In-situ treatment process options applicable to groundwater are limited to in-situ biological treatment/biodegradation. This option is evaluated for effectiveness, implementability, and cost.

In-Situ Biological Treatment (Biodegradation) – In-situ biological treatment of groundwater uses similar scientific principles as ex-situ biological treatment and is achieved by injecting carbon, nutrients, and bacteria into the aquifer to enable native microorganisms to metabolize the target contaminants. Treatment could require a large number of deep borings/wells for introduction of the nutrients and microorganisms to the groundwater system.

Effectiveness: Low. In-situ biological treatment is not effective for groundwater in the Wells Formation aquifer because of the large flow and depth to groundwater.

Implementability: Low. In-situ biological treatment could be difficult to implement for groundwater in the Wells Formation aquifer due to the number of deep wells required and the difficulty dispersing the carbon and nutrients throughout the aquifer.

Cost: High capital costs. Moderate O&M costs.

Site-Specific Considerations: In-situ biological treatment could be effective for removing selenium in groundwater; however, treatment would require a large number of borings/wells and removal effectiveness would be contingent on the selenium species present.

Applicability Within the Site: In-situ biodegradation could be applicable for treatment of alluvial or Wells Formation groundwater.

Decision Rationale: In-situ biological treatment is not retained due to low effectiveness and implementability for groundwater in the Wells Formation aquifer.

5.2.8 Monitored Natural Attenuation

MNA may be used in conjunction with the above-mentioned technologies and process options to achieve remedial objectives for groundwater. Natural processes can contribute to the reduction of COC concentrations in areas where releases and transport have already occurred. In groundwater, MNA can occur through physical (e.g., dilution, dispersion, sorption), geochemical (e.g., sorption, precipitation), and biochemical (biologically-mediated reduction) processes. MNA would be applicable to alluvial and Wells Formation groundwater at the Smoky Canyon Mine Site. This technology is evaluated for effectiveness, implementability, and cost.

> Effectiveness: Low. MNA could be effective for removing selenium in groundwater.
>
> Implementability*:* High. MNA is a natural physical, chemical, and/or biological process that is readily implementable and could be most successful where the geochemical environment and hydraulic conditions are favorable for attenuation to occur.
>
> Cost: Low capital costs. Low O&M costs.
>
> Site-Specific Considerations: Sorption and biologically mediated MNA processes are dependent on geochemical conditions in the alluvial and Wells Formation aquifers at the Site.
>
> Applicability Within the Site: MNA could be applicable for alluvial and Wells Formation groundwater.
>
> Decision Rationale: MNA is retained for alluvial and Wells Formation groundwater as a complimentary remedy component.

5.3 Surface Water

Retained technologies and process options for surface water are further screened against the effectiveness, implementability, and cost criteria (Table 5-3).

5.3.1 No Action

No Further Action – The No Further Action alternative would entail no additional work at the Site. NTCRAs that have already been implemented would continue. Pilot treatability studies would be terminated. As discussed in the RI/FS guidance (USEPA 1988), the No Action alternative is required by the NCP as a baseline for comparison with other remedial technologies.

Effectiveness: Moderate. The 2006 and 2013 NTCRAs have significantly reduced the loading of selenium to the environment from the Pole Canyon ODA. Selenium concentrations have been reduced to below water quality standards in Pole Canyon Creek as a result of these actions. However, there would be no additional actions to reduce infiltration into overburden materials in ODAs at the Site.

Implementability: High. The No Further Action alternative is easily implementable because it requires no additional work at the Site. Operation and maintenance activities for the Pole Canyon ODA NTCRAs would continue.

Cost: No additional capital costs. No O&M costs (the costs for the Pole Canyon NTCRAs are included in the baseline alternative, i.e., zero for the detailed analysis).

Site-Specific Considerations: No further actions would be taken.

Applicability Within the Site: The No Further Action alternative is required by the NCP.

Decision Rationale: The No Further Action alternative is required by the NCP as a baseline against which other alternatives are compared and is retained for the development of remedial alternatives.

5.3.2 Institutional Controls/Access Controls

Options that are applicable to surface water are institutional controls (administrative orders/consent decrees and information programs) and access controls (fences/gates). Evaluation of each of these process options for effectiveness, implementability, and cost is provided below.

Administrative Orders/Consent Decrees – Administrative orders/consent decrees could be used to require monitoring and reporting of the performance and effectiveness of a remedy.

Effectiveness: High. Administrative orders and consent decrees are legally binding and may be enforced at a relatively low cost. They are effective in requiring monitoring or reporting of the performance and effectiveness of a remedy.

Implementability: High. Enforcement tools such as administrative orders and consent decrees may be issued unilaterally or negotiated by the Agencies participating in the RI/FS process at the mine and are easy to implement.

Cost: Low capital costs. Low O&M costs.

Site-Specific Considerations: Administrative orders and consent decrees are effective in requiring monitoring or reporting on the performance and effectiveness of a remedy.

Applicability Within the Site: Administrative orders and consent decrees are applicable for evaluation of the effectiveness of remedies implemented throughout the Site.

Decision Rationale: Administrative orders and consent decrees are effective in requiring monitoring for performance and effectiveness and are retained for the development of remedial alternatives.

Signs – Signs convey information on land use or land-use restrictions; materials used to produce the sign must last for the length of time that the warning will be posted. Signs posted at seep areas could be used to notify people that drinking the water is potentially unsafe.

Effectiveness: Moderate. Signage is moderately effective in notifying people that drinking the water in certain creeks/springs at the Site is potentially unsafe.

Implementability: High. Posting signs is easy to implement.

Cost: Low capital costs. Low O&M costs.

Site-Specific Considerations: Signage is moderately effective in notifying people that drinking the water in certain creeks/springs at the Site is potentially unsafe.

Applicability Within the Site: Posting signs would be applicable at Hoopes Spring and at South Fork Sage Creek springs.

Decision Rationale: Institutional controls such as signs are retained for use as part of an overall Site remedy.

Fences/Gates – Fencing could be used to restrict access and prevent direct exposure to surface water in seeps and detention basins (i.e., restrict large animal access). Fencing is typically part of an overall Site remedy.

Effectiveness: Moderate. Fencing is effective for restricting access and preventing exposure to selenium and arsenic in surface water in seeps and detention basins at the Site.

Implementability: High. The materials and equipment are readily available and building a fence to restrict access to seeps and detention basins would be easy to implement.

Cost: Low capital costs. Low O&M costs.

Site-Specific Considerations: Fencing is effective in preventing large animal exposure to selenium and arsenic in surface water but would not prevent access to smaller animals or birds.

Applicability Within the Site: Fencing is potentially applicable to areas that have unacceptable risks.

Decision Rationale: Fencing is effective at limiting large animal access and preventing direct exposure to selenium and arsenic on the Site. Fencing is typically part of an overall Site remedy and is retained for use with other remedial technologies.

5.3.3 Containment

Containment options that are applicable to surface water include engineered cover systems (for example multi-layer covers using Dinwoody, Chert/Limestone, and/or Geosynthetic layers) which could be used to cover overburden areas, rock covers (Chert/Limestone cover) which could be used to cover seeps and/or detention basins, and sediment control features (dikes and berms, detention basins). Evaluation of these containment options for effectiveness, implementability, and cost is provided below. Note that the components of these types of covers were evaluated in detail in Section 5.2.3 for groundwater (because selenium migrates through groundwater to surface water).

Chert/Limestone Cover – Chert/Limestone or other constituents could be used as a physical barrier layer on seeps and/or detention basins to prevent direct contact with surface water containing selenium and/or arsenic. This was pilot tested at the ES-5 seep (NewFields 2004a) and at the D-P10 catch basin (NewFields 2004b).

Effectiveness: High. A Chert/Limestone rock cover is proven effective in preventing direct contact with surface water in seeps and/or detention basins.

Implementability: High. Chert/Limestone rock covers are implementable and are composed of proven, effective materials that have been used at the Site.

Cost: Low capital costs. Low O&M costs.

Site-Specific Considerations: Chert/Limestone is readily available in the Rex Chert Member at the Site and could be effective in preventing direct contact with surface water in seeps and/or detention basins.

Applicability Within the Site: Chert/Limestone or other constituents are applicable for use as a rock cover on seeps and/or detention basins.

Decision Rationale: Chert/Limestone or other constituents could be effective as a barrier layer on seeps and/or detention basins and is retained for the development of remedial alternatives.

Dinwoody Cover – Containment of overburden sources using Dinwoody covers or other multi-layer cover systems are likely to be critical component of an overall surface water remedy.

Effectiveness: Moderate to High. Dinwoody covers could be moderately to highly effective in reducing infiltration to overburden and subsequent leaching and transport of selenium and arsenic to surface water. Containing the overburden source would be expected to reduce selenium concentrations in downstream surface water.

Implementability: High. Dinwoody covers are implementable because they are constructed using conventional techniques and the cover materials are available at the Site.

Cost: Moderate capital costs. Low to moderate O&M costs.

Site-Specific Considerations: Dinwoody covers are effective in containing overburden material and in controlling the source of selenium to surface water.

Applicability Within the Site: Dinwoody covers are applicable to ODAs that are sources of selenium to seeps and detention basins at the Site.

Decision Rationale: Containment of overburden using a Dinwoody cover is a potential component of an overall surface water remedy. This option is retained.

Geosynthetic Cover – Containment of overburden sources using a Geosynthetic cover (GM/GCL) is likely to be a critical component of an overall surface water remedy.

Effectiveness: Moderate to High. An engineered Geosynthetic cover could be effective in reducing infiltration to overburden and subsequent leaching and transport of selenium and arsenic to surface water.

Implementability: Moderate. Engineered multi-layer covers that include a GM or GCL are implementable because they are constructed using conventional techniques.

Cost: High capital costs. High O&M costs.

Site-Specific Considerations: Geosynthetic covers are effective in containing overburden material and in controlling the source of selenium and arsenic to surface water.

Applicability Within the Site: Geosynthetic covers are applicable to ODA that are sources of selenium to surface water at the Site.

Decision Rationale: Containment of overburden using a multi-layer Geosynthetic cover is a potential component of an overall surface water remedy. This option is retained.

Sediment Control Features (Dikes and Berms) – Dikes and berms reduce or eliminate loading of sediment in streams. Grading and shaping of the land during remedial actions allows for management of storm water infiltration and runoff. Control of storm water, surface runoff, and sediment are likely to be key components of an overall surface water remedy.

Effectiveness: Moderate. Dikes and berms are moderately effective in managing surface water infiltration and storm water runoff while controlling erosion.

Implementability: High. Dikes and berms are readily implementable using conventional construction techniques.

Cost: Low capital costs. Low O&M costs.

Site-Specific Considerations: Dikes and berms are effective in managing surface water infiltration and runoff while controlling erosion.

Applicability Within the Site: Dikes and berms are applicable for controlling storm water runoff and sediment mobilization around ODAs and other mine features.

Decision Rationale: Dikes and berms are effective in managing storm water runoff and controlling erosion and can reduce sediment migration and are retained for development of alternatives.

Sediment Control Features (Detention Basins) – Detention basins, or sedimentation basins or ponds, detain storm water runoff allowing sediments to settle out of the water. A portion or all of the surface water is retained in the pond and may either evaporate or infiltrate into the ground below. Control of storm water, surface runoff, and sediment are likely to be critical components of an overall surface water remedy.

Effectiveness: Moderate. Detention basins are moderately to highly effective in settling and removing sediment from storm water and moderately effective at minimizing contaminant volume. Detention basins are also moderately effective in reducing the transport of selenium and arsenic off Site.

Implementability: High. Detention basins are readily implementable using conventional construction techniques.

Cost: Low capital costs. Low O&M costs.

Site-Specific Considerations: Retaining contaminated surface water in detention basins is used at the Site and is effective in preventing surface migration to local creeks.

Applicability Within the Site: Detention basins are applicable in remedial construction areas and areas where contaminated surface water could flow off Site.

Decision Rationale: Detention basins are effective in reducing the transport of selenium to local creeks and are retained for development of alternatives.

5.3.4 Source Control and Routing

Source control and routing technologies and process options for surface water are limited to diversion (open/closed channels). Evaluation of this option for effectiveness, implementability, and cost is provided below.

Diversion (Open/Closed Channels) – Diversion channels could be used to divert surface water around an ODA or convey water to a treatment facility and are likely to be a critical component of an overall Site surface water remedy.

Effectiveness: High. Diversion channels are effectively used in the 2006 NTCRA at the Pole Canyon ODA to convey the flow in Pole Canyon Creek around the ODA (bypass pipeline) and to direct run-on from the slopes adjacent to the Pole Canyon ODA into the creek downstream (run-on control channel). They could be applicable to other areas of the Site to reduce contact between surface flow and overburden.

Implementability: High. Diversion channels are easy to implement using conventional construction equipment.

Cost: Low capital costs. Low O&M costs.

Site-Specific Considerations: Open/closed channels are an effective means of diverting surface water around ODAs or conveying water to a treatment facility at the Site.

Applicability Within the Site: Diversion channels are applicable for preventing run-on to and diverting surface water around ODAs. Channels are also applicable for conveying surface water to a treatment facility.

Decision Rationale: Open/closed diversion channels are effective in conveying surface water and are typically part of an overall Site remedy and are retained for development of alternatives.

5.3.5 Removal and Disposal

Removal and disposal technologies and process options applicable to surface water are limited to surface water disposal. This option is evaluated for effectiveness, implementability, and cost.

Surface Water Disposal (Discharge to Onsite Treatment or Other Storage/Disposal Facility) – Surface water discharged at seeps could be routed to an onsite treatment or other storage/disposal facility. Surface water disposal would be applied with ex-situ treatment as part of an overall Site remedy. Collection of surface water in creeks is not feasible and is not discussed further.

Effectiveness: High. Surface water at seeps could be collected and conveyed to treatment systems at the Site. Considerations would need to be made for winter conditions. For example, seep flow at the toe of the Pole Canyon ODA could be collected and routed to a nearby treatment system or other storage/disposal facility.

Implementability: High. Routing surface water discharge from seeps to a nearby treatment or other storage/disposal facility is implementable.

Cost: Low capital costs. Low O&M costs.

Site-Specific Considerations: Collection of seep water is feasible.

Applicability Within the Site: Discharge of surface water to an onsite treatment facility is applicable for the Pole Canyon ODA seep. Seep flows and selenium concentrations are shown in Table 4-2. As shown, the Pole Canyon ODA seep has by far the highest load and is a candidate for treatment.

Decision Rationale: Discharge of surface water to an onsite treatment or other storage/disposal facility is retained for the Pole Canyon ODA seep.

5.3.6 Ex-Situ Treatment

Ex-situ treatment technologies and process options potentially applicable to surface water include a variety of physical (gravity/mechanical separation, media filtration, and ultrafiltration/reverse osmosis), chemical (chemical precipitation and oxidation/reduction), and biological (biodegradation) technologies. Evaluation of each of these options for effectiveness, implementability, and cost is provided below.

Gravity/Mechanical Separation – Gravity or mechanical methods could be used to separate suspended solids from surface water. Gravity separation involves settling of suspended solids in ponds, basins, or tanks, using baffles or other devices. Mechanical separation involves using belt presses, filter presses, or vacuum filtration units to remove suspended solids.

> Effectiveness: Low. Gravity/mechanical separation is not effective for surface water with dissolved selenium.
>
> Implementability: Low. Gravity/mechanical separation is implementable for dewatering waste streams from other treatment technologies but is not implementable for dissolved selenium in surface water.
>
> Cost: Moderate capital costs. Moderate O&M costs.
>
> Site-Specific Considerations: Gravity/mechanical separation is applicable for dewatering waste streams from other treatment technologies. It would not remove dissolved selenium from surface water at the Site.
>
> Applicability Within the Site: Not applicable to Site conditions.
>
> Decision Rationale: Gravity/mechanical separation is not retained because it is not effective for dissolved contaminants in surface water at the Site.

Media Filtration – Media filtration is a separation process that uses granular material through which influent water flows to filter suspended solids. Media filtration (i.e., sand filtration) is not a stand-alone treatment but is effective in trapping suspended solids on top of and within the sand filter bed while allowing effluent to flow through it.

> Effectiveness: Moderate. Media filtration (typically using sand) is proven effective for removing suspended solids; however, the technology is not effective for dissolved selenium and arsenic in surface water.
>
> Implementability: Low. Not implementable as a stand-alone treatment system and not applicable to contaminated surface water at the Site.
>
> Cost: Moderate capital costs. Moderate O&M costs.

Site-Specific Considerations: Media filtration (typically using sand) is proven effective for removing suspended solids and trapping the particles on/in a filter bed in conjunction with other technologies. It is not effective for dissolved selenium and arsenic in surface water in seeps and ponds.

Applicability Within the Site: Not applicable to Site conditions.

Decision Rationale: Media filtration is not retained because it is not applicable to contaminated surface water at the Site.

Ultrafiltration/Reverse Osmosis – Ultrafiltration/reverse osmosis is a membrane-filtration technology that could be used to separate and concentrate selenium and arsenic in surface water. The pore size of the ultrafiltration membrane is slightly larger than the pore size of the reverse osmosis membrane. This technology would require further treatment to remove selenium and arsenic from the concentrate stream prior to discharge.

Effectiveness: Moderate. Ultrafiltration/reverse osmosis is a membrane-filtration technology that is effective in removing selenium from surface water. However, the effectiveness is generally lower for high flow/low concentration waters and for low flow/high concentration waters.

Implementability: Low. Not implementable as a stand-alone treatment system.

Cost: High capital costs. High O&M costs.

Site-Specific Considerations: Although ultrafiltration/reverse osmosis technologies are proven effective for selenium removal and have been tested at the Hoopes WTP Pilot Study, the Site conditions do not favor its use for surface water (either due to high flow/low concentration water in creeks or to low but seasonally variable flow/high concentration water in the Pole Canyon ODA seep).

Applicability Within the Site: Could be applicable to the Pole Canyon ODA seep, but PRB technology is more applicable.

Decision Rationale: Ultrafiltration/reverse osmosis is not retained because it has a lower effectiveness and higher cost than PRB technology for treatment of the Pole Canyon ODA seep.

Chemical Precipitation – Chemical precipitation involves the precipitation of dissolved ions/salts in the form of insoluble salts by adding chemicals to reach chemical saturation and/or varying the pH. The insoluble salts may be removed from the water by sedimentation, coagulation, and/or flocculation.

Effectiveness: Low. Chemical precipitation is effective for reduced forms of selenium. The treatment process generates a sludge that requires further treatment.

Implementability: Low. Chemical precipitation is not implementable for surface water in seeps and ponds at the Site.

Cost: Moderate capital costs. High O&M costs.

Site-Specific Considerations: Chemical precipitation is more effective for reduced forms of selenium. Because selenium at the Site generally occurs in oxidized forms, additional steps may be required for removal efficiency.

Applicability Within the Site: Chemical precipitation is not applicable for surface water in seeps and ponds that requires treatment.

Decision Rationale: Chemical precipitation is not retained due to relatively lower effectiveness when compared to other treatment options.

Oxidation/Reduction – The chemical oxidation/reduction process uses agents such as oxidation, chlorination, hydrogen peroxide, and ultraviolet light to react with and oxidize contaminants in surface water. Oxidation/reduction reactions may improve the separation characteristics for removal of selenium if used in conjunction with other treatment technologies.

Effectiveness: Low. Oxidation/reduction is more effective for reduced forms of selenium and less effective for oxidized forms. Oxidation/reduction is not effective as a stand-alone treatment.

Implementability: Low. The implementability of oxidation/reduction is low because it is not a stand-alone treatment technology and is not applicable to surface water in seeps and detention basins at the Site.

Cost: Moderate capital costs. High O&M costs.

Site-Specific Considerations: Oxidation/reduction is more effective for reduced forms of selenium. Because selenium at the Site generally occurs in oxidized forms, additional steps may be required for removal efficiency.

Applicability Within the Site: Oxidation/reduction is not applicable for surface water in seeps and ponds that requires treatment.

Decision Rationale: Oxidation/reduction is not retained due to relatively lower effectiveness when compared to other treatment options.

Ex-Situ Biological Treatment (Biodegradation) – Biological treatment involves the degradation or reduction of contaminants by microorganisms. Surface water is extracted or pumped to a process location (e.g., wetlands, anaerobic bioreactor, or fluidized bed bioreactor) for treatment. Metals and other inorganic contaminants could be removed from the water using anaerobic bacteria and then precipitated or absorbed by the media in the wetlands or bioreactor.

Effectiveness: High. Biodegradation is effective as part of an active water treatment plant such as an anaerobic fluidized bed bioreactor.

Implementability: Moderate. Ex-situ biodegradation is moderately implementable depending on the flows and concentrations of contaminants.

Cost: Moderate capital costs. Moderate O&M costs.

Site-Specific Considerations: Ex-situ biological treatment is proven effective at the Hoopes WTP Pilot Study fluidized bed bioreactor (FBR). However, in-situ biodegradation would be more effective for the Pole Canyon ODA seep, which has seasonally-varying flows and concentrations.

Applicability Within the Site: Ex-situ biological treatment is not applicable for surface water in seeps and ponds that requires treatment.

Decision Rationale: Ex-situ biological treatment is not retained because Site conditions favor in-situ treatment.

5.3.7 In-Situ Treatment

In-situ treatment technologies and process options applicable to surface water are limited to in-situ biological treatment (biodegradation). This option is evaluated for effectiveness, implementability, and cost.

In-Situ Biological Treatment – In-situ biological treatment of surface water uses similar scientific principles as ex-situ biological treatment and is achieved by introducing carbon, nutrients, and possible bacteria into the water to enable native microorganisms to metabolize the target contaminants. A passive flow system (e.g., wetlands, bioreactor, or PRB) constructed directly in the seep or pond location could be used for selenium removal. For a PRB, reactive media is placed in a trench aligned perpendicular to flow such as to intercept and treat contaminated water. To treat selenium, the reactive media uses chemical and microbial processes to chemically reduce and transform selenium from selenate to selenite and ultimately to elemental selenium. Reactive material suitable to treat selenium includes inert sand, wood chips, and alfalfa hay. Various factors influence the reduction speed of microbial processes, including pH, temperature, and salinity.

Effectiveness: High. Biodegradation is effective as a passive treatment technology for residual seeps following source controls (e.g., covering overburden).

Implementability: High. In-situ biodegradation is implementable and could be most successful where the geochemical environment and hydraulic conditions allow for control of the key growth variables (e.g., temperature, pH, and nutrients).

Cost: Moderate capital costs. Moderate to high O&M costs.

Site-Specific Considerations: Passive in-situ biological treatment, such as a PRB, is effective for removing selenium and could be used at seeps and ponds at the Site.

Applicability Within the Site: In-situ biodegradation is potentially applicable for the Pole Canyon ODA seep and for detention ponds.

Decision Rationale: In-situ biological treatment is retained because a passive treatment technology such as a PRB could be effective for treatment of seep and pond water.

5.4 Smoky Canyon Mine FS Technical Memorandum #2

Following Agency review and approval of Smoky Canyon Mine FSTM#1, FSTM#2 will be prepared in accordance with RI/FS Guidance Under CERCLA (USEPA 1988) to develop and screen remedial alternatives. The selected representative technologies for the impacted Site media (solids and soils, groundwater and surface water) will be assembled into remedial alternatives that represent a range of institutional controls and containment/engineered covers and treatment combinations. As described in the RI/FS guidance, the alternatives may be media-specific or if there are significant interactions among different media, they may be site-wide alternatives.

The assembled alternatives will be screened for effectiveness, implementability, and cost and the best or most promising will be retained for further consideration and analysis. Remedial alternatives carried through the screening process will be further refined and then individually evaluated in detail with respect to nine evaluation criteria (overall protection of human health and the environment; compliance with ARARs; long-term effectiveness and permanence; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability; cost; state acceptance; and community acceptance). A comparative analysis will be performed to evaluate the relative performance of each alternative to identify the advantages and disadvantages of the alternatives relative to one another and the key tradeoffs that must be balanced for selection of a final remedy for the Smoky Canyon Mine.

TABLE 5-1. Evaluation of Technologies for Solids and Soils

Technology/Process Option	Effectiveness	Implementability	Cost	Site-Specific Considerations	Applicability Within the Site	Decision Rationale	Solids/Soils Screening Result
NO ACTION							
No Action							
No Further Action	Moderate	High	No Capital No O&M	No further actions would be taken.	Required by the National Contingency Plan (NCP).	No further action is retained as required by the NCP to provide a baseline against which other alternatives can be compared.	Retained
INSTITUTIONAL CONTROLS / ACCESS CONTROLS							
Institutional Controls							
Land-Use Controls / Grazing Controls	High	High	Low Capital Low O&M	Land-use controls are effective in limiting access and preventing activities that could compromise the integrity of remedial actions.	Land-use controls are applicable for areas of the Site on public lands.	Land-use controls are effective in limiting access and preventing exposure to selenium and arsenic in overburden materials and are retained.	Retained
Administrative Orders / Consent Decrees	High	High	Low Capital Low O&M	Enforcement tools are effective in requiring the performance of monitoring or reporting on the effectiveness of a remedy.	Administrative orders and consent decrees are applicable for evaluation of the effectiveness of a remedy such as a cover system.	Administrative orders/consent decrees are effective in requiring effectiveness monitoring and reporting and are retained.	Retained
Information Programs	High	High	Low Capital Low O&M	Information programs are effective in restricting activities that could compromise remedial actions and in notifying the public that covered contamination remains at the Site.	Information programs are applicable for areas of the Site on public lands.	Information programs are retained for use with other remedial technologies.	Retained
Access Controls							
Fences / Gates	Moderate	High	Low Capital Low O&M	Fencing is effective in preventing large animal exposure to selenium in soil and vegetation on ODAs but would not prevent access to smaller animals or birds.	Fencing is potentially applicable to areas that have unacceptable risks (for example soil at seeps or ponds).	Fencing is effective at limiting access and direct exposure to selenium and arsenic in soils and overburden material on the Site. Fencing is typically part of an overall Site remedy and is retained.	Retained
CONTAINMENT							
Engineered Covers							
Chert / Limestone Cover	High	High	Moderate Capital Low O&M	Chert/Limestone is readily available in the Rex Chert Member at the Site and is proven effective in preventing vegetation from rooting.	Chert/Limestone is applicable as a capillary break layer and/or a barrier layer in different cover types.	Chert/Limestone is effective as a barrier layer or a water conveyance layer and is typically combined with other materials for an effective cover system and is retained.	Retained
Dinwoody Cover	High	High	Moderate Capital Low O&M	Dinwoody Formation material is available at the Site and is proven effective in preventing contact with overburden material. Dinwoody material could be used as a single layer or as a component in combination with other materials in a multi-layer cover (i.e., Enhanced Dinwoody Cover currently in use at Panel F).	Dinwoody material is applicable as a soil layer with a low saturated hydraulic conductivity and a high moisture storage capacity that would support vegetation growth as part of a barrier cover system.	Dinwoody material is effective in preventing direct contact with overburden, is present at the Site, and can support vegetation growth. Dinwoody material could be combined with other materials in a multi-layer cover system and is retained.	Retained
SOURCE CONTROLS AND ROUTING							
Surface Controls							
Grading / Erosion Control	Moderate	High	Low to Moderate Capital Low O&M	Grading could be implemented to increase or direct water runoff and as part of installation of a cover. Erosion control is effective in reducing the migration of solids from covered or uncovered areas.	Grading is applicable for eliminating areas where pooling of water occurs and to manage surface water infiltration. Erosion control is applicable for use during and after cover construction to reduce transport of solids by storm water runoff.	Grading/erosion controls are retained for use in cover construction due to their benefit during construction and on covered/uncovered areas in reducing transport of solids in storm water.	Retained
Vegetation	Moderate	High	Moderate Capital Low O&M	Vegetation is effective in stabilizing surface materials, reducing erosion potential, and increasing evapotranspiration. Species management could also reduce selenium uptake.	Vegetation is applicable for use on covered and uncovered ODAs at the Site.	Vegetation is an effective element of cover systems and could be used to stabilize surfaces and reduce selenium uptake on covered and uncovered areas and is retained.	Retained
Slope Stabilization							
Slope Reduction / Retaining Walls	Moderate	High	Low to Moderate Capital Low O&M	Slope stabilization was used in the 2013 Pole Canyon NTCRA and is readily implementable using conventional construction techniques.	Slope reduction and retaining walls are applicable for stabilization of slopes during construction of cover systems on ODAs.	Slope stabilization is retained for use in conjunction with cover construction.	Retained

TABLE 5-1. Evaluation of Technologies for Solids and Soils

Technology/Process Option	Effectiveness	Implementability	Cost	Site-Specific Considerations	Applicability Within the Site	Decision Rationale	Solids/Soils Screening Result
REMOVAL AND DISPOSAL							
Removal							
Excavation	High	High	Low to High Capital Low to Moderate O&M	Conventional excavation of overburden solids/soils is not effective or implementable for pit backfill or overburden material in external ODAs. Excavation is effective and implementable for small volumes of materials such as sediment in seep areas or ponds and treatment residuals.	Excavation may be applicable for small volumes of materials.	Excavation is not applicable for overburden solids/soil and is not retained. Excavation is retained for small volumes of sediment and/or in-situ treatment residuals.	Retained for Small Volumes
Disposal							
Onsite Consolidation / Disposal	High	High	Low Capital Low O&M	Onsite consolidation/disposal of overburden solids/soils is readily implementable and effective using conventional construction techniques. Onsite consolidation/disposal is effective for small volumes of material such as sediment in seep areas or ponds and treatment residuals.	Onsite consolidation/disposal is not applicable because existing mine pits have already been backfilled and overburden material has already been consolidated into ODAs. However, onsite consolidation/disposal may be applicable for small volumes of material from sedimentation basins or seep areas.	Onsite consolidation/disposal is not applicable for overburden solids/soils and is not retained. Onsite consolidation/disposal is retained for small volumes of material such as seep or pond sediment and/or treatment residuals.	Retained for Small Volumes
Offsite Disposal	High	Low to High	High Capital No O&M	Offsite disposal is not implementable for the large volumes of overburden solids/soils at the Site. Offsite disposal is effective and implementable for small volumes of material such as treatment residuals.	Offsite disposal is not applicable because the overburden material at the Site has already been consolidated into ODAs onsite. However, offsite disposal may be applicable for small volumes of material.	Offsite disposal is not applicable for overburden solids/soils and is not retained. Offsite disposal is retained for small volumes of material such as treatment residuals.	Retained for Small Volumes
SOILDS AND SOILS TREATMENT							
Ex-Situ Treatment							
Stabilization / Fixation	Low	Low	Very High Capital Low O&M	Ex-situ stabilization/fixation is not effective or implementable for immobilizing contaminants in overburden solids and soils.	Ex-situ stabilization/fixation is not applicable for treatment of the large volumes of overburden solids and soils at the Site.	Ex-situ stabilization/fixation is not retained because it is not effective or implementable for conditions found at the Site.	NOT Retained
In-Situ Treatment							
Stabilization / Fixation	Low	Low	High Capital Low O&M	In-situ stabilization/fixation is not effective or implementable for immobilizing contaminants in overburden solids.	In-situ stabilization/fixation is not applicable for treatment of the large volumes of overburden solids at the Site.	In-situ stabilization/fixation is not retained because it is not effective or implementable for conditions found at the Site.	NOT Retained

TABLE 5-2. Evaluation of Technologies for Groundwater

Technology/Process Option	Effectiveness	Implementability	Cost	Site-Specific Considerations	Applicability Within the Site	Decision Rationale	Groundwater Screening Result
NO ACTION							
No Action							
No Further Action	Moderate	High	No Capital No O&M	No further actions would be taken.	Required by the National Contingency Plan (NCP).	No further action is retained as required by the NCP to provide a baseline against which other alternatives can be compared.	Retained
INSTITUTIONAL CONTROLS							
Institutional Controls							
Administrative Orders / Consent Decrees	High	High	Low Capital Low O&M	Enforcement tools could be effective in requiring groundwater monitoring to evaluate the effectiveness of containment/source control remedies at the Site.	Administrative orders and consent decrees are applicable for compliance monitoring at the Site.	Administrative orders/consent decrees are effective in requiring effectiveness monitoring and reporting and are retained.	Retained
Deed Restrictions	Moderate	High	Low Capital Low O&M	Deed restrictions could be implemented to prevent the use of groundwater with selenium or arsenic concentrations above MCLs as a domestic water supply.	Deed restrictions are applicable on Simplot-owned land in Sage Valley.	Deed restrictions could be effective in protecting people until the remedy becomes effective and are retained.	Retained
CONTAINMENT							
Engineered Covers							
Tailings Cover	Moderate	Low	Moderate Capital Moderate O&M	Tailings material is available at the Area B tailings impoundments.	Tailings material is potentially applicable for use as a layer in a multi-layer cover system to reduce infiltration into ODAs.	Because tailings material could be highly erodible on an ODA slope, it is not suitable as a surface material but could be used as a subsurface layer (though it would be difficult to place on a slope during cover construction). Erodibility on slopes and performance make tailings less desirable than other materials that are available at the Site so the tailings cover is eliminated.	NOT Retained
Chert / Limestone Cover	High	High	Moderate Capital Low O&M	Chert/Limestone is readily available in the Rex Chert Member at the Site and is proven effective in preventing vegetation from rooting.	Chert/Limestone is applicable as a capillary break layer and/or a barrier layer in different cover types.	Chert/Limestone is effective as a barrier layer or a water conveyance layer and is typically combined with other materials for an effective cover system and is retained.	Retained
Dinwoody Cover	High	High	Moderate Capital Low O&M	Dinwoody Formation material is available at the Site and is proven effective in reducing infiltration and the mobility of selenium. The volume and suitability of the Dinwoody material on Site still needs to be evaluated.	Dinwoody material is applicable as a soil layer with a low saturated hydraulic conductivity to reduce infiltration and a high moisture storage capacity that would support vegetation growth as part of a multi-layer cover system.	Dinwoody material is effective in reducing infiltration to overburden and is present at the Site. Dinwoody material could be combined with other cover layers and is retained.	Retained
Geosynthetic Cover (GM/GCL)	High	Moderate	High Capital High O&M	Geosynthetic covers are effective in limiting infiltration and reducing the mobility of selenium but are more difficult to implement than other types of covers because of problems related to tearing the membrane.	Geosynthetic covers are applicable as a low permeability layer of a multi-layer cover system.	Geosynthetic cover layers are effective in reducing infiltration into the ODAs but have lower implementability and higher capital and O&M costs relative to other types of cover layers. Geosynthetic covers are retained.	Retained
SOURCE CONTROLS AND ROUTING							
Diversion							
Open / Closed Channels	High	High	Low Capital Low O&M	Open or closed channels are effective means of conveying groundwater that discharges to the surface at springs to a treatment facility at the Site.	Diversion channels are applicable for conveying groundwater to a treatment facility.	Diversion channels are effective in conveying groundwater and may be used as part of an overall Site remedy and are retained.	Retained

TABLE 5-2. Evaluation of Technologies for Groundwater

Technology/Process Option	Effectiveness	Implementability	Cost	Site-Specific Considerations	Applicability Within the Site	Decision Rationale	Groundwater Screening Result
REMOVAL AND DISPOSAL							
Removal							
Extraction Wells	Low	High	High Capital Low O&M	Use of extraction wells upgradient of Hoopes Springs is unlikely to be effective due to known hydrogeologic complexities. Groundwater reports to the surface at Hoopes Spring and South Fork Sage Creek Springs and can be collected for treatment there if necessary.	Extraction wells are not applicable for groundwater at the Site.	Hoopes Spring acts as a regional groundwater discharge feature and effectively captures the migration of COCs within Wells Formation groundwater. Groundwater reports to the surface without the need for extraction wells.	NOT Retained
Groundwater Disposal							
Discharge to Onsite Treatment or Other Storage/Disposal Facility	High	High	Low Capital Low O&M	Discharge of groundwater from Hoopes Spring and South Fork Sage Creek springs to an onsite treatment or other storage/disposal facility would require a conveyance system. Piping and pumps are currently in place and effectively convey groundwater to the Hoopes Water Treatment Plant (WTP) Pilot Study.	Groundwater conveyance/discharge to an onsite treatment or other storage/disposal facility is applicable in areas where MCLs are exceeded in alluvial or Wells Formation groundwater.	Discharge of extracted groundwater to an onsite treatment or other storage/disposal facility is effective and is retained.	Retained
GROUNDWATER TREATMENT							
Ex-Situ Treatment							
Gravity / Mechanical Separation	Low to High	High	Moderate Capital Moderate O&M	Gravity/mechanical separation is used to settle waste streams in the Hoopes WTP Pilot Study and effectively removes reduced, elemental selenium from groundwater at the Site.	Gravity/mechanical separation is applicable for dewatering waste streams from other treatment technologies.	Gravity/mechanical separation is retained for use with other treatment technologies and is effective in removing reduced, elemental selenium from groundwater.	Retained
Media Filtration	High	High	Moderate Capital Moderate O&M	Media filtration (typically using sand) is proven effective for removing suspended solids and trapping the particles on/in a filter bed at the Hoopes WTP Pilot Study.	Media filtration is applicable as a component of an overall treatment system for groundwater at the Site.	Media filtration is retained for use with other treatment technologies and is proven effective for removing suspended solids in groundwater.	Retained
Ultrafiltration / Reverse Osmosis	High	High	High Capital High O&M	Ultrafiltration/reverse osmosis (UF/RO) technologies are proven effective for reducing selenium concentrations in groundwater at the Site and have been tested at the Hoopes WTP Pilot Study.	Ultrafiltration/reverse osmosis (UF/RO) is applicable as a component of an overall treatment system for groundwater that discharges at Hoopes Spring.	Ultrafiltration/reverse osmosis (UF/RO) technologies are retained because they are proven effective for producing concentrated selenium water for additional treatment and have been tested at the Hoopes WTP Pilot Study.	Retained
Chemical Precipitation	Low	High	Moderate Capital High O&M	Chemical precipitation is more effective for reduced forms of selenium. Because selenium at the Site generally occurs in oxidized forms, additional steps may be required for removal efficiency.	Chemical precipitation could be applicable for groundwater treatment but would require additional treatment trains.	Chemical precipitation is not retained due to low effectiveness for oxidized selenium.	NOT Retained
Oxidation / Reduction	Low	High	Moderate Capital High O&M	Oxidation/reduction is more effective for reduced forms of selenium. Because selenium at the Site generally occurs in oxidized forms, additional steps may be required for removal efficiency.	Oxidation/reduction could be applicable for groundwater treatment but would require additional treatment trains.	Oxidation/reduction is not retained due to low effectiveness for oxidized selenium.	NOT Retained
Biodegradation	High	High	Moderate Capital Moderate O&M	Ex-situ biological treatment is proven effective for removing selenium at the Hoopes WTP Pilot Study fluidized bed bioreactor (FBR). Microbial reduction of selenate and selenite to elemental selenium allows for easier removal of selenium by other technologies in the treatment train.	Ex-situ biological treatment is applicable for groundwater that discharges at Hoopes Spring and South Fork Sage Creek springs.	Ex-situ biological treatment is retained because it is effective for reducing selenium concentrations in groundwater and has been tested at the Site. As determined by design and operations testing, other process options may be required to support an ex-situ biological treatment system.	Retained
In-Situ Treatment							
Biodegradation	Low	Low	High Capital Moderate O&M	In-situ biological treatment could be effective for removing selenium in groundwater; however, treatment would require a large number of borings/wells and removal effectiveness would be contingent on the selenium species present.	In-situ biodegradation could be applicable for treatment of alluvial or Wells Formation groundwater.	In-situ biological treatment is not retained due to low effectiveness and implementability for groundwater in the Wells Formation aquifer.	NOT Retained
Natural Physical/Chemical/Biological Treatment							
Monitored Natural Attenuation (MNA)	Low	High	Low Capital Low O&M	MNA could be effective for removing selenium in groundwater; however, sorption and biologically-mediated MNA processes are dependent on geochemical conditions in the alluvial and Wells Formation aquifers at the Site.	MNA could be applicable for Wells Formation and alluvial groundwater.	MNA is retained for Wells Formation and alluvial groundwater.	Retained

TABLE 5-3. Evaluation of Technologies for Surface Water

Technology/Process Option	Effectiveness	Implementability	Cost	Site-Specific Considerations	Applicability Within the Site	Decision Rationale	Surface Water Screening Result
NO ACTION							
No Action							
No Further Action	Moderate	High	No Capital No O&M	No further action would be taken.	Required by the National Contingency Plan (NCP).	No further action is retained as required by the NCP to provide a baseline against which other options can be compared.	Retained
INSTITUTIONAL CONTROLS / ACCESS CONTROLS							
Institutional Controls							
Administrative Orders / Consent Decrees	High	High	Low Capital Low O&M	Enforcement tools are effective in requiring monitoring and reporting on the performance and effectiveness of a remedy.	Administrative orders and consent decrees are applicable for evaluation of the effectiveness remedies implemented throughout the Site.	Administrative orders and consent decrees are effective in requiring monitoring for performance and effectiveness and are retained.	Retained
Signs	Moderate	High	Low Capital Low O&M	Signage is moderately effective in notifying people that drinking the water in certain creeks/springs at the Site is potentially unsafe.	Posting signs would be applicable at Hoopes Spring and at South Fork Sage Creek Springs.	Institutional controls such as signs are retained for use as part of an overall Site remedy.	Retained
Access Controls							
Fences/Gates	Moderate	High	Low Capital Low O&M	Fencing is effective in preventing large animal exposure to selenium in surface water but would not prevent access to smaller animals or birds.	Fencing is potentially applicable to areas that have unacceptable risks.	Fencing is effective at limiting large animal access and direct exposure to selenium in surface water on the Site. Fencing is typically part of an overall Site remedy and is retained.	Retained
CONTAINMENT							
Engineered Covers							
Chert / Limestone Cover	High	High	Low Capital Low O&M	Chert/Limestone is readily available in the Rex Chert Member at the Site and could be effective in preventing direct contact with surface water in seeps and/or detention basins.	Chert/Limestone is applicable for use as a rock cover on seeps and/or detention basins.	Chert/Limestone could be effective as a barrier layer on seeps and/or detention basins and is retained.	Retained
Dinwoody Cover	Moderate to High	High	Moderate Capital Low to Moderate O&M	Dinwoody material is available at the Site and is proven effective in containing overburden material and controlling the source of selenium to surface water.	Dinwoody covers are applicable to ODAs that are sources of selenium to surface water at the Site.	Dinwoody material is effective in reducing infiltration to overburden and is present at the Site. Dinwoody material could be combined with other cover layers and is retained.	Retained
Geosynthetic Cover (GM/GCL)	Moderate to High	Moderate	High Capital High O&M	Geosynthetic covers are effective in containing overburden material and controlling the source of selenium to surface water but are more difficult to implement than other types of covers because of problems related to tearing the membrane.	Geosynthetic covers are applicable as a low permeability layer of a multi-layer cover system on ODAs that are a source of selenium to surface water.	Geosynthetic cover layers are effective in reducing infiltration into the ODAs but have lower implementability and higher capital and O&M costs relative to other types of cover layers. Geosynthetic covers are retained.	Retained
Sediment Control Features							
Dikes and Berms	Moderate	High	Low Capital Low O&M	Dikes and berms are effective in managing surface water infiltration and runoff while controlling erosion.	Dikes and berms are applicable for controlling storm water runoff and sediment mobilization around ODAs.	Dikes and berms are effective in managing runoff and controlling erosion and are retained.	Retained
Detention Basins	Moderate	High	Low Capital Low O&M	Retaining contaminated surface water in detention basins is used at the Site and is effective in preventing surface migration to local creeks.	Detention basins are applicable in remedial construction areas and areas where contaminated surface water could flow off Site.	Detention basins are effective in reducing the transport of selenium to local creeks.	Retained
SOURCE CONTROLS AND ROUTING							
Diversion							
Open / Closed Channels	High	High	Low Capital Low O&M	Open/closed channels are effective means of diverting surface water around ODAs or conveying water to a treatment facility at the Site.	Diversion channels are applicable for preventing run-on to and diverting surface water around ODAs. Channels are also applicable for conveying surface water to a treatment facility.	Open/closed diversion channels are effective in conveying surface water and are typically part of an overall Site remedy.	Retained

TABLE 5-3. Evaluation of Technologies for Surface Water

Technology/Process Option	Effectiveness	Implementability	Cost	Site-Specific Considerations	Applicability Within the Site	Decision Rationale	Surface Water Screening Result
DISPOSAL							
Surface Water Disposal							
Discharge to Onsite Treatment or Other Storage/Disposal Facility	High	High	Low Capital Low O&M	Collection of seep water is feasible.	Discharge of surface water to an onsite treatment or other storage/disposal facility is applicable for the Pole Canyon ODA seep.	Discharge of surface water to an onsite treatment or other storage/disposal facility is retained for the Pole Canyon ODA seep.	Retained
SURFACE WATER TREATMENT							
Ex-Situ Treatment							
Gravity / Mechanical Separation	Low	Low	Moderate Capital Moderate O&M	Gravity/mechanical separation is applicable for dewatering waste streams from other treatment technologies. It would not remove dissolved selenium from surface water at the Site.	Gravity/mechanical separation is not applicable to Site conditions.	Gravity/mechanical separation is not retained because it is not effective for dissolved contaminants in surface water at the Site.	NOT Retained
Media Filtration	Moderate	Low	Moderate Capital Moderate O&M	Media filtration (typically using sand) is proven effective for removing suspended solids and trapping the particles on/in a filter bed in conjunction with other technologies. It is not effective for dissolved selenium in surface water in seeps and ponds.	Media filtration is not applicable to Site conditions.	Media filtration is not retained because it is not applicable to contaminated surface water at the Site.	NOT Retained
Ultrafiltration / Reverse Osmosis	Moderate	Low	High Capital High O&M	Although ultrafiltration/reverse osmosis technologies are proven effective for selenium removal and have been tested at the Hoopes WTP Pilot Study, the Site conditions do not favor its use for surface water (either due to high flow/low concentration water in creeks or to low but seasonally variable flow/high concentration water in the Pole Canyon ODA seep).	Could be applicable to the Pole Canyon ODA seep, but PRB technology is more applicable.	Ultrafiltration/reverse osmosis is not retained because it has a lower effectiveness and higher cost than PRB technology for treatment of the Pole Canyon ODA seep.	NOT Retained
Chemical Precipitation	Low	Low	Moderate Capital High O&M	Chemical precipitation is more effective for reduced forms of selenium. Because selenium at the Site generally occurs in oxidized forms, additional steps may be required for removal efficiency.	Chemical precipitation is not applicable for surface water in seeps and ponds that requires treatment.	Chemical precipitation is not retained due to relatively lower effectiveness when compared to other treatment options.	NOT Retained
Oxidation / Reduction	Low	Low	Moderate Capital High O&M	Oxidation/reduction is more effective for reduced forms of selenium. Because selenium at the Site generally occurs in oxidized forms, additional steps may be required for removal efficiency.	Oxidation/reduction is not applicable for surface water in seeps and ponds that requires treatment.	Oxidation/reduction is not retained due to relatively lower effectiveness when compared to other options.	NOT Retained
Biodegradation	High	Moderate	Moderate Capital Moderate O&M	Ex-situ biological treatment is proven effective at the Hoopes WTP Pilot Study fluidized bed bioreactor (FBR). However, in-situ biodegradation would be more effective for the Pole Canyon ODA seep, which has seasonally-varying flows and concentrations.	Ex-situ biological treatment is not applicable for surface water in seeps and ponds that requires treatment.	Ex-situ biological treatment is not retained because Site conditions favor in-situ treatment.	NOT Retained
In-Situ Treatment							
Biodegradation	High	High	Moderate Capital Moderate to High O&M	Passive in-situ biological treatment, such as a permeable reactive barrier (PRB), is effective for removing selenium and could be used at seeps and ponds at the Site.	In-situ biodegradation is potentially applicable for the Pole Canyon ODA seep and for detention ponds.	In-situ biological treatment is retained because a passive treatment technology such as a PRB could be effective for treatment of seep and pond water.	Retained

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